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A Model for an English-Polish Systematic Dictionary of Chemical Terminology

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An English-Polish Systematic Dictionary of Chemical Terminology

Introduction

Terms matter. The past century has seen a dramatic upsurge in the number of terms, one that might be described as a terminological boom, to borrow the expression from J. Lukszyn and W. Zmarzer (2006: 125). It is unlikely that the trend will come to a standstill anytime soon. Much as the observed proliferation of terms was brought about by rapid advances spanning various fields of human activity, it also enabled and facilitated them. For progress to be possible, the idea underlying it, whether it concerns a new discovery, invention or innovation, needs to be expressed, communicated (in the broadest sense of the word), and understood. Otherwise, regardless of its originality, novelty and ingenuity, the idea stands no chance of exerting any effect on society and will eventually fall into oblivion. Accordingly, specialised communication, whose aim can be best described as "affecting the special knowledge structure by means of a technique not available in general communication" (Sager, Dungworth, and McDonald 1980: 69), is of paramount importance for the development of any field, and so are linguistic units that frequently feature in specialised communication, viz. terms.

Given the vital role ascribed to specialised communication, the need arises to facilitate this process. Provided that specialised communication occurs in text form, this undoubtedly complex challenge has a clearly linguistic aspect to it, which is why one may reasonably expect linguistics or its related disciplines not only to address the challenge but also to contribute to overcoming it. One question to which an answer has been and continues to be sought could broadly be framed as follows: how can humans be assisted in the production and reception of specialised texts so that specialised knowledge can be communicated, understood, and acquired with greater ease, accuracy and speed? Of the many solutions that have been proposed, terminological dictionaries seem particularly promising. This is not only due to the venerable tradition of their successfully serving to describe various properties of terms, but also to their flexibility as specialised language models, a flexibility which has manifested itself in the rich diversity of the already published works regarding their scope, size, function and structure. While there is no escaping the fact that much progress has been made in the field of terminological dictionaries, there are still hurdles that remain to be cleared and niches that are yet to be filled. One such challenge is the compilation of terminological dictionaries that accurately represent systems of terms rather than treat individual terms as existing in isolation from one another. This study attempts to make a contribution towards that goal.

As the title suggests, the present book aims to develop a model for an English-Polish systematic dictionary of chemical terminology. Although a considerable body of works devoted to terminological dictionaries exists, systematic dictionaries have hitherto received only scant attention. Yet the few references to them that can be found in the literature lead one to the conclusion that through their unique features, i.e. their focus on representing the terminology of a subject-field as a network of interrelated terms, they may offer their users benefits that others do not. For this reason alone, in the predominantly user-centred lexicography of today, the issues related to their compilation and use warrant attention. However, their structure also raises questions that are of the utmost import for terminology as a field of study, further adding to their relevance.

The model of the dictionary to be developed in this book is intended to acquaint the dictionary's users with the most important terms used in the field of chemistry in a way that will help them not only to understand basic chemical concepts but also to see the link between individual terms, thus providing them with more than a mere list of terms, their definitions, and their equivalents. Additionally, the dictionary will also offer help to its users when it comes to determining the order in which to study terms. As regards the target group that the dictionary may be especially useful for, it includes native Polish users who are beginners when it comes to English chemical terminology and would like to study it or revise it in a systematic manner.

This book comprises two main parts. The first part consists of two chapters and presents the theoretical and practical considerations concerning the compilation of the dictionary. The second part comprises a single chapter and mainly features the proposed dictionary, thus illustrating the principles discussed in part one. Dictionary models do not always include any illustrative material for the final dictionary and this may be justified. It is hoped, however, that the ample material provided here will help to exemplify the underlying principles better. Additionally, the dictionary part is intended to ensure that the model works in practice and not only in theory, to paraphrase M. Rundell (2012). A more-detailed description of the structure of the book is given below.

Chapter 1 explores issues that are relevant for the subject of the dictionary, i.e. chemical terminology, thus laying the terminological foundations for the model. It opens with a discussion of the term *terminology* and follows it up by focusing on the term *term*. Both *terminology* and *term* are key words for this book and each of them can be understood in various ways. Hence their meanings require at least a little clarification. Building on the preceding part, the chapter then looks at a selection of term-like units and a subdivision of terms proper. Such classifications heavily depend on the definition of *term* and the classification presented is no exception to this rule. The remainder of the chapter is devoted to chemistry and its terminology. An attempt is made to give an overview of chemistry, so that a link can be established between the discipline and certain properties of its terminology. The latter seem to exhibit a number of features that are interesting from both a terminologist's and terminographer's perspectives.

Chapter 2 centres around the object selected to model English-Polish terminology, i.e. the systematic dictionary, thus laying the terminographic foundations for the model. First, it discusses terminography as a field of study and contrasts it with related fields, so that an insight can be gained into their mutual relationships. Next, it briefly characterises terminological dictionaries, of which the proposed dictionary is an example, and takes a closer look at the principles for their compilation, paying particular attention to the issues relevant for the present book. Then, the focus shifts to systematic dictionaries as a separate dictionary type. Drawing on the existing literature, the chapter describes their typical features and comments on their significance. The chapter culminates with a presentation of the assumptions for the model of the dictionary that were followed when creating the dictionary in Chapter 3. In particular, the chapter details the dictionary's aims and target group and both their implications for the macrostructure and microstructure of the dictionary. The rationale for the choices made is given whenever appropriate.

Chapter 3 is the most immediately practical part of the book. It features the English-Polish systematic dictionary of chemical terminology divided into 10 thematic modules, each exemplifying the principles and assumptions discussed in the preceding parts. The chapter also includes a brief user's manual, placed before the main body of the dictionary, as well as an English-Polish index, a Polish-English index, and an English-Polish list of chemical elements, all of which follow the main body of the dictionary.

Chapter 1

Terminological Foundations of the Model

1.1. The many meanings of *terminology*

In some fields of scholarly inquiry it is a commonplace that a learned publication – be it a monograph, a chapter in a monograph, a journal paper or a conference paper, etc. – devotes at least a little space to explaining what is meant by the terms that are used. Such explanations are necessary whenever the author introduces a new term or redefines an already existing one but they also occur when an existing term is liable to several interpretations and the author wants to clarify which interpretation they intend to follow. Even a cursory look at linguistic literature is most likely to reveal that linguistics is a good case in point here.

It is also not uncommon that the discussion of the meaning of some terms used in a book is accompanied by the author's decrying the use of certain terminology in their discipline. Again the field of linguistic works amply illustrates this. For instance, H. Borer states that "Within the area of aktionsart and *aspect*, terminological proliferation as well as terminological confusion is rampant" (Borer 2005: 34). Similar claims could be made, and indeed they have been made, in numerous areas of linguistics (Couper-Kuhlen 1986: 1, Declerck and Reed 2001: 6, Norde 2009: 109–120, to cite but a few examples).

It seems fitting that the present book should also begin with a discussion of some of the terms it uses, in particular *term* and *terminology*. Apart from the usual aims of discussing the terminology used, such as setting the scene for the subsequent parts of the book and clarifying the terms that could otherwise be prone to unintended and undesirable interpretations, a more specific one will be pursued. Metaterminological in nature, it involves establishing whether terminology as a discipline has succeeded in living up to the ideals of linguistic precision as espoused and advocated by some of its proponents, especially within the Wüsterian tradition (see Temmerman 2000: 10–14).

The word *terminology* is polysemous. This fact, well-documented in publications on terminology, “has obsessed many writers on the subject and confused many interpretations of otherwise clearly argued texts” (Sager 1994: 375). In (1997) *Glossary of terms used in terminology* by B. de Bessé, B. Nkwenti-Azeh, and J.C. Sager, the reader may find three separate entries that are of interest here. These are labelled *terminology 1*, *terminology 2* and *terminology 3* and their respective definitions are given below (de Bessé, Nkwenti-Azeh, and Sager 1997: 154, numbers added here)[1]:

> (1) The study of terms, **concepts**, and their relationships.
>
> (2) The set of practices and methods used for the collection, description, and presentation of terms.
>
> (3) The **vocabulary** of a **subject field**.

The inclusion of three different entries in the glossary might be interpreted as meaning that according to its authors *terminology* corresponds to three different senses or concepts. This three-way distinction can be expanded by consulting the two entries and thus the two definitions for *vocabulary*. These are presented below (de Bessé, Nkwenti-Azeh, and Sager 1997: 156):

> (4) A set of words or terms.
>
> (5) A **reference work** which contains the words or terms which are representative for a **subject field**.

It should be clear from definitions 1–5 that they are strongly related to one another, which justifies treating *terminology* as a polysemous word rather than a homonym. In what follows all of the senses indicated above will be analysed according to the order in the glossary.

In the first sense (‘the study of terms’), *terminology* is understood to refer to a specific discipline with its own object of study. Several other words have been used to refer to *terminology* in roughly the same sense, including

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[1] In all quotations, original emphasis has been retained.

terminology science (e.g. Felber 1984: 96), *theory of terminology* (e.g. Simonnæs 2007: 129; also when used in the phrase *general theory of terminology*, Felber 1984: 97) and *terminology studies* (e.g. Rogers 2015: 49). Admittedly, these are not absolute synonyms and as such cannot be used interchangeably. Use of one rather than any other often results from a conscious decision as to which theoretical framework within terminology an author subscribes to. In particular, the first designation (*terminology science*) has proved controversial. J.C. Sager, a leading figure in British terminology studies attributes its first appearance in English-language publications to Austrian and German writers and dismisses it as being pseudo-English (Sager 1994: 377) and constituting "a tautologous barbarism" (Sager 1994: 378). Despite the cogency of his reasoning, the term had already found its way into the official documents of the International Organisation for Standardisation (ISO), becoming part of international English ISO terminology[2] and surviving in ISO standards to this day (e.g. ISO 2017).

As a field of study, terminology has a rich history but its breakthrough moment came in the 1930s, which saw the publication of books by E.Wüster, E. Drezen and D. Lotte, the "spiritual fathers of modern terminology" (Picht 2011: 9). Although each of them left their own mark on terminology studies, only E.Wüster lived long enough to continue his work on terminology for many years after the war, leaving behind a rich and diverse *œuvre*, as evidenced by his impressive list of publications (see Lang, Lang, and Reiter 1979) and an equally impressive track record of organisational work (see Felber and Lang 1979). Since the 1930s, the field has developed dynamically, with the exception of a hiatus brought about by the Second World War. As a result, numerous strands of research into terminology have emerged. Some scholars speak of various terminological schools. For instance, M.T. Cabré (1998: 7) distinguishes between three schools: the Austrian school, the Soviet school, and the Czech school. Others prefer to focus on different approaches or theories of terminology. By way of example, M.-C. L'Homme, U. Heid, and J.C. Sager (2003: 152–154) mention the following: general theory of terminology, socioterminology, textual terminology, communicative theory of terminology, and sociocognitive theory of terminology. The list could be expanded by adding the approach followed by F. Riggs (1981) and a relatively new approach that has been labelled frame-based

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[2] This contributed to the British Standards Institution's decision to withdraw from any further work in the appropriate ISO committee (Sager 1994: 380).

terminology (Faber and López Rodríguez 2012: 22–31), which draws on the developments in frame semantics. Although these theories or approaches do share some common ground, they differ with respect to the object that they study, the methods that they use and the aims that they pursue. In light of this, the emerging picture of terminology is a composite one despite it being a relatively young field of study.

Complementary to the first sense of *terminology* is the second one ('set of practices'), where the focus is placed on the practical aspects of dealing with terminology, thus mirroring the often-invoked theory/practice distinction. Other designations that are sometimes used in roughly the same sense include *terminology work* and *terminography*. The former has been criticized for not conforming to English compound formation patterns for semantic reasons (Sager 1994: 378–379), but it has persisted (e.g. in ISO standards) despite opposition to it[3]. *Terminography*, meanwhile, is the English translation of a term coined by A. Rey (1995: 129) and bears close structural resemblance to the term *lexicography*. Even though both terminology and lexicography have a lot in common, A. Rey (1995: 129–130) contrasts them with regard to the subject fields covered, the methods, and the theoretical presuppositions[4].

While one may argue about when exactly terminology developed into a discipline, it does not seem controversial to state that practical terminology predates its theory-oriented counterpart. Lending support to this claim are studies into the beginnings of lexicography. Their findings suggest that some of the oldest dictionaries contained terminology ordered thematically (McArthur 1986: 32–33). This was for instance the case of *HAR-ra = hubullu*, an artefact of Mesopotamian lexicography, which is a thematic collection of twenty four tablets, the first two of which deal with administrative and legal terminology (Civil 1976: 125). The compilation of HAR-ra in circa the 18th century BC (Considine 2016: 605) and other ancient works including terms is testament to the practical terminological activity being performed about four thousand years ago. It also demonstrates how the need to record terminology was present in ancient Mesopotamia and that terminology was already by then deemed worthy of attention.

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[3] It is interesting to note here that the phrase was also used by the very same J.C. Sager (1998: 262) who opposed its adoption into English.

[4] The lexicography/terminography distinction is also touched upon in Chapter 2.

Although it would clearly be wrong to reduce the long history of writing on terminology to practically-oriented texts, many of them were created as a response to the pressing practical problems faced at the time. This could be argued for C. Linnaeus, the father of biological taxonomy, A.L. Lavoisier, the father of modern chemistry, and W. Whewell[5], an English philosopher and historian. But even E. Wüster, whose contribution to the development of terminology as a discipline can hardly be questioned, was clearly driven by practical goals, as evidenced by his *Internationale Sprachnormung in der Technik*, in which he sees terminological standardisation as a necessary step in overcoming problems occurring in the international exchange of technical ideas (1970: 1–6).

Practical needs may have played an important role in the historical development of terminology *qua* a field of study but advances in terminology have also been made without practical implications in mind. Writing on the resonance of certain theoretical considerations among terminological practitioners, J.C. Sager (1990: 9) remarks:

> Such topics, primarily of interest to theorists, have, however, found little echo in the discussion of the people directly concerned with terminology processing, notably in term banks.

Later he continues (1990: 9):

> In recent years little new theoretical work is being produced that can be considered to be relevant to the applied nature of terminology.

Two comments are worth making here. First, since the publication of the above words, the number of terminology-related topics that are primarily relevant to theorists, has grown significantly, which corresponds to the growing understanding that terminology studies transcends the confines of an applied

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[5] While the history of terminology studies in the 20th century is relatively well-documented, studies into earlier approaches to terminological issues are by and large lacking. Those that do exist tend to be written by specialists in the respective discipline or historians/philosophers of science, which inevitably affects their perspective. Occasional references to ideas on terminology before the 20th century that can be found in terminological literature can hardly fill this gap. In particular, the ideas of William Whewell deserve further investigation on account of the originality of his musings regarding the nature of terms as well as his personal involvement in the creation of new English terms (Michta 2017).

field of study, which is what J.C. Sager seems to have interpreted terminology to be. Of the research tasks for terminology listed by J. Lukszyn and W. Zmarzer (2006: 11–12), only a few can be said to be applied in nature. Second, the claim regarding the gulf between theory and practice in terminology needs to be re-examined in light of recent publications. Some of the new developments that have been reported in the literature encompass innovative projects in terminography that stem from the successful fusion of existing methods in terminology with those from other fields. The EcoLexicon project (Faber and San Martin 2011) draws on frame semantics, the DiCoInfo project incorporates ideas from meaning-text theory (L'Homme 2008), and the projects developed within termontography rely heavily on ontology engineering (Temmerman and Kerremans 2003). All of them have shown how advances in terminology studies can translate into innovative compilations of terminology. Given its growing importance for practical applications (see Pearson 1998, Łukasik 2014), it would be a grave omission not to mention corpus linguistics here, even if it is only to be done in passing. Since the introduction of corpus linguistic methods into terminology, their myriad benefits have been reaped in both theoretical and practical studies, but their tremendous potential is yet to be fully tapped.

To conclude the discussion about the first and the second senses of *terminology*, a note about their mutual relationship seems in order. It should be clear from the remarks made so far that these two senses can be differentiated from each other. It is equally true that there has been a strong connection between the study of terminology and the processing thereof, making them complementary rather than competitive. While practical needs may have acted as a driving force that led to the establishment of terminology as a field of study and in many ways defined the directions it took, its developments have informed practical applications, suggesting a symbiotic relationship between the two.

The last two senses of *terminology* can be established following the distinction of *vocabulary* into 'a set of words or terms' and 'a reference work'. The relationship that exists between them is akin to that between *grammar* 'a set of rules in a language' and *grammar* 'a reference book about rules in a language'. What all these four senses share is a common pattern by which two of their senses are distinguished, thus constituting a case of regular polysemy (Apresjan 1973: 16).

Although these two senses of *terminology* appear last in the glossary by B. de Bessé, B. Nkwenti-Azehand, and J.C. Sager, it seems that the 'set of terms' sense originated first, as the existence of terms predates the emergence of the field. The historical primacy of the ‘set of terms’ sense finds its confirmation in the *Oxford English Dictionary*, in which the first quotation in the entry for *terminology*, dated 1770, relates to precisely that sense (OED Online 2018). Moreover, the same sense clearly prevails in general usage, which is corroborated by the fact that the LDOCE, one of the so-called ‘Big Five’ learners’ dictionaries (Bejoint 2010: 164), includes it as the only meaning (LDOCE Online 2018). Both of these facts suggest that, at least in general use, this is the central sense of the word. Since the glossary’s authors did not explain their policy with regard to sense ordering, one may only speculate as to what their motives were[6].

Despite certain misgivings regarding the reasons for the exact ordering of meanings in the glossary, it cannot be dismissed as wrong since the authors did not make them explicit. However, the wording of definitions 3–5 poses more important problems that stem from its ambiguity. First, the choice of the word *vocabulary*, even if it is qualified with the phrase *of a subject field*, in definition 3 renders terminology extremely inclusive and thus generates problems that could easily have been avoided had the definition been reformulated. One could argue that the words *do*, *which* or *thing* belong to the vocabulary of a subject field, e.g. chemistry, the main reason for their inclusion being the fact that they can certainly be attested in specialised chemical texts. Since the original definition does not impose any additional criteria upon classifying the vocabulary of a subject field as terminology, there is nothing in it that precludes the words *do*, *which* and *thing* from being counted as terminology. And yet it seems few terminologists would agree that these words should be elevated to the status of being a term.

This generous approach seems to be reinforced in definitions 4–5. Implicit in both of them is the suggestion that vocabulary encompasses at least two classes: those known as *words* and those known as *terms*. What is more, a hint is also made at their mutual exclusivity: a word is not a term and *vice versa*, a view that will be commented on in the following subchapter. Finally, a strict interpretation of definition 4 in conjunction with definition 3 leads to the conclusion that terminology does not have to include any terms at all. A similar

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[6] Even more puzzling is the fact that in some lexicographical works the ‘set of terms’ sense is omitted altogether. In an otherwise excellent *Dictionary of Lexicography* by R.R.K. Hartmann and G. James, the central meaning of ‘set of terms’ is not included at all (1998: 140).

point can be made with reference to definition 5. This is not only counterintuitive but also seems to be plainly inaccurate.

The question that raises itself is whether the problems with definitions 3–5, as pointed out above, could have been avoided, had a different wording been opted for. After all, it is widely accepted that defining a word clearly, concisely, and accurately is far from easy (Landau 2001: 154, Béjoint 2010: 320). In this case, however, it seems that by introducing minor changes, this could be achieved. Instead of having 3 definitions of terminology, 4 could be included, with the third and fourth being defined in the following way:

> (3) A set of terms used in a subject field.
>
> (4) A reference work which contains terms which are representative for a subject field.

In doing so, the glossary still includes the same general meanings but without falling into the trap of referring to *vocabulary*. Granted, further objections could be raised against these definitions, for example that they explain *terminology* by referring to *term*, a potentially unknown word, but if *term* is defined in the glossary, this seems to be a minor inconvenience.

If there is any common denominator for definitions 1–5 discussed in this subchapter, then it must be the term *term,* to which all of them refer (in the case of definition 3 this is not indirectly). Since the meaning of *terminology* hinges on that of *term,* in order to fully understand the former, attention has also to be paid to the latter.

1.2. The term *term*

The term *term* enjoys a central position in terminology studies, one that is similar to that of the term *word* in lexicology or the term *meaning* in semantics. It has been defined and redefined numerous times to the point that it now boasts an abundance of definitions, which reflect the plurality of perspectives from which terms can be viewed but also indicate that the matter has generated controversy. Apart from having important theoretical consequences for terminology studies, the question *What is a term?* is also of great practical significance as it can be employed for the purposes of term identification, often a first stage in practical projects dealing with terminology.

Some scholars have claimed that term identification poses little difficulty (Nuopponen 1996: 1069):

> An experienced terminologist or terminographer finds the information he is searching [for] quickly from special language texts, even if he is not very familiar with the subject field in question. He can distinguish between terms and non-terms, related concepts, different classifying criteria, etc.

While this passage clearly shows appreciation and perhaps even admiration for the skills of terminologists and terminographers, the rosy picture painted in it seems to overstate their almost boundless expertise and downplay the difficulty of their task. There are certainly good and even excellent terminologists and terminographers who perform their duties accurately, effectively and quickly but even they may come a cropper when dealing with new terminology from a field that they are well-versed in, let alone one they are not very familiar with, especially when the texts they are working with are poorly written or the new terms are explained badly or not at all. Further proof is provided by the varying quality of terminological dictionaries, which frequently exhibit flaws, even when such works were prepared by experienced terminologists/terminographers (Łukasik 2007a: 33–35).

A question that readily suggests itself upon reading the quote by A. Nuopponen is: what criteria do terminologists and terminographers use to distinguish terms from non-terms? One answer could be that they use a definition of the term *term* or rather definitions, as there are many. In the glossary quoted previously, one may find the following definition:

> (6) A **lexical unit** consisting of one or more than one word which represents a **concept** inside a **domain**.

Since the three items in bold are defined in the said glossary, their definitions are quoted below so that a better understanding can be gained of the authors' views on what a term is (de Bessé, Nkwenti-Azeh, and Sager 1997: 154).

> lexical unit
> (7) A word consisting of more than one lexical item.

> concept
> (8) An abstract unit which consists of the **characteristics** of a number of concrete or abstract **objects** which are selected according to specific scientific or conventional criteria appropriate for a **domain**.
>
> domain
> (9) The **subject field**, area of knowledge, discipline, production process, or method in which a **concept** is being used.

Even a cursory glance at definitions 6–9 suggests that these have not been drafted carefully enough. If definition 6 is read in conjunction with definition 7, they seem to lead to undesirable consequences, which becomes evident if the wording of definition 7 is substituted for *lexical unit* in definition 6:

> A (word consisting of more than one lexical item) consisting of one or more than one word which represents a **concept** inside a **domain**.

What this wording states is that a term must consist of at least two lexical items. Consequently, *atom*, *reactant,* and *alloy* (all examples taken from chemistry) could not be classed as terms as they each consist of a single lexical item only. This formal condition which concerns the composition of terms seems rather surprising. So much so that one may wonder whether the authors of the glossary, all of them perfectly competent to compile a glossary like this, let it slip through by failing to check how the definitions of *term* and *lexical unit* are related to each other. Incidentally, this glossary seems to contradict A. Nuopponen's statement discussed earlier.

Term can also be defined by contrasting it with *word*. An example follows (Sager 1990: 19):

> The items which are characterised by special reference within a discipline are the 'terms' of that discipline, and collectively they form its 'terminology'; those which function in general reference over a variety of sublanguages are simply called 'words', and their totality the 'vocabulary'. Since the number of lexical elements in a language is finite, some items have to do double duty, so that words may be pressed into service as terms in particular special languages (e.g. 'noise' in communication theory).

A few remarks are in order here. As is clear from the above quote, for J.C. Sager words contrast with terms, thus establishing two mutually exclusive classes of items within a lexicon of a special language. Terms cannot be words and *vice versa*. This contrastive juxtaposition of terms with words is not just confined to the writings of J.C. Sager. Other authors have also used it in a similar vein (Pearson 1998: 7), especially when trying to underline the differences between the former and the latter. M. Rogers (2015: 51), however, finds this usage problematic, as:

> word and term cannot be considered as parallel in special languages and general language, that is as *Fachwort* and *Wort* respectively, since a term may consist of more than one word.

Elsewhere in the same book, Sager uses *word* not as a counterpart of *term* with a more general meaning, but as an umbrella term that covers the two classes of a lexicon of a special language (Sager 1990: 55–56). For a careful reader, the use of *word* in two clearly distinct senses may not pose excessive difficulty as they will be able to discern both of senses. As regards those uninitiated in terminological texts, their comprehension of J.C. Sager's conception may be hampered as a result.

Another comment worth making concerns the criteria that J.C. Sager employed when establishing his distinction between words and terms. If one accepts that terms are those items of a lexicon of a special language that are characterised by special reference within a discipline, then clearly their counterpart should be words defined as those items which are characterised by general reference in that discipline, otherwise the distinction is not an exhaustive one. As currently formulated, the definitions of *word* and *term* jointly imply that there may well be items in the lexicon of a specialised language that are neither words nor terms. By using the qualification "over a variety of sublanguages", J.C. Sager essentially subdivides units which function in general reference into those which do so "over a variety of sublanguages", and other units, for which this additional condition does not apply. While the former class is constituted by words, the other does not seem to have a specific name. Unfortunately, the author fails to provide any justification for introducing a non-exhaustive distinction into words and terms.

A different definition of *term* is given by I. Burkhanov (2010: 239–240), who states:

> A term is a *one-word* or *multiple-word lexical item* that denotes an *expert concept*; for instance, a *scientific concept*. In this respect, terms are different from lexical items of the *general vocabulary*, because the *meanings* of the latter are rather based on *commonsense concepts*.

His definition exhibits a number of strengths:

1) It makes it clear that terms can be both one-word and multi-word items.
2) Instead of focusing on contrasting words with terms, it contrasts terms with lexical items of the general vocabulary, which is not laden with problems of interpretation encountered in J.C. Sager's definition.
3) By clearly indicating the words in the definition which have been given entry status in the remainder of the dictionary, it helps in gaining a clearer idea of what he understands terms to be.
4) By subsuming scientific concepts under expert concepts, it offers an inclusive approach to terms which is not limited to terms denoting scientific concepts. By doing so it precludes all those terms that denote expert concepts other than scientific ones from being the object of terminology.
5) Finally, it offers a distinction between meanings and concepts, which is clarified in the respective entries for *meaning* and *concept*. The meaning/concept distinction, to which E. Wüster (1991: 1–2) set great store, has been used repeatedly in writings on terminology (e.g. Felber 1984: 103, Temmerman 2000: 4–6), however the contrast between them has not always been identical, which is why clarifying it was a useful decision on I. Burkhanov's part.

There are certain elements that could perhaps be improved in the definition. For instance, it does not make clear which of the senses of the polysemous words in italics are meant, rendering its understanding more challenging for the reader than it could otherwise have been. One could also point to the fact that what the definition essentially does is delegate some of the responsibility for explaining to the entries for *expert concepts* and *common sense concept*. This is a strategy that is generally unavoidable in dictionaries that provide definitions for entries. However, its success is predicated on the quality of the explanations provided in the pertinent entries that are referred to and these do not exhibit the same level of clarity as the entry for *term*. Notwithstanding these (minor) reservations, it has to be noted that the dictionary is not one of terminology but of lexicography, which makes the quality of the definition even more praiseworthy.

The last definition that will be discussed here has been penned by J. Lukszyn and W. Zmarzer[7] (2006: 23):

> a term is a linguistic sign that belongs to the lexicon of a technolect and denotes a concept in a system of semantic relations typical of said lexicon.

Later the authors go on to illustrate the interdependencies between the elements of their definition and briefly define them with the use of the schematic below:

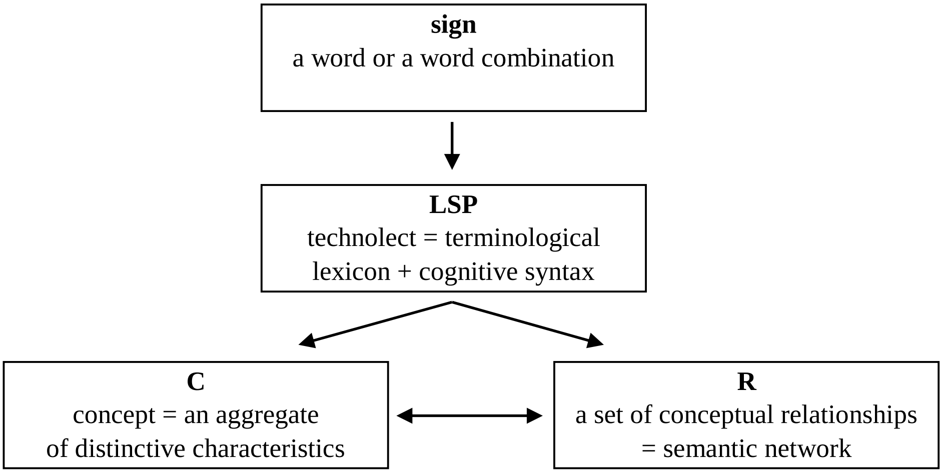

Fig. 1. The notion of term (adapted from Lukszyn and Zmarzer 2006: 23)

Close parallels can be discerned between J. Lukszyn and W. Zmarzer's approach and either of the approaches discussed earlier. In fact, it also displays a varying degree of similarity with a number of other definitions and descriptions of *term* that have been proposed by other authors. The reason for this might lie in the fact

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[7] "termin to znak językowy należący do leksykonu określonego technolektu i oznaczający pojęcie w systemie relacji semantycznych właściwych dla tego leksykonu". All translations from Polish are mine.

that J. Lukszyn and W. Zmarzer arrived at their definition by presenting the ideas and definitions expressed in 14 different publications and distilling what they described as the essence of the concept of *term*. Clearly embedded in previous literature, their definition brings together many previous descriptions of *term* into a coherent whole. Of particular note here is the reference to "a set of conceptual relationships", which will be explored later.

While identifying points of divergence between various approaches to terms can be a fruitful exercise, it remains undeniable that there is also much common ground to be found in them. When one juxtaposes a number of ideas concerning the nature of a term and considers the discrepancies between them, be they subtle or profound, it might be tempting to question the validity of some of them or describe *term* as a somewhat flawed term. It might be equally appealing to discern a certain irony in the fact that a field whose *raison d'être* was once seen as facilitating communication is riddled with problems regarding the polysemy of its most fundamental term (see also Hoffman 1985: 160), which originally it opposed (Picht and Draskau 1985: 100, Wüster 1974: 62–64, Wüster 1991: 87). There are, however, other possible interpretations. One may arrive at the conclusion that *term* is a perfect illustration of the dynamic and multi-faceted nature of numerous other terms. Rather than being static, *term* has been undergoing constant change, its definition being formulated and reformulated numerous times, a phenomenon not dissimilar to that of many other terms in other fields of enquiry. Another factor that has contributed towards the emergence of a plethora of *term* definitions is that terms (regardless of their exact definition) are in a sense multidimensional. They can be analysed from various angles, giving rise to differing and sometimes competing definitions. This semantic flexibility of *term* has proven to be a strength, as it allows new definitions to be drafted which incorporate the findings of new studies into terms. Without it one might expect to find that progress in terminology studies had been hampered.

1.3. Classifying terms and related linguistic units

Even though only a fraction of existing definitions of *term* were discussed in the previous chapter, it has been shown that while there is common ground between them there are also important differences between individual approaches. Alongside other factors, this fact has led some authors to conclude that "The holy grail of defining the terms in a coherent framework remains elusive and perhaps illusory” (Rogers 2015: 58). One explanation that suggests itself is that the problem is linked to the boundary between terms and non-terms. However, another explanation can also be posited. Defining terms might pose a difficulty because terms are a heterogenous class. This is the focus of the present subchapter.

As terms are linguistic signs, they can be classified using the same analytic frameworks that are applied in general lexicology. There are also dedicated frameworks that have been developed with a view to investigating terminology only. The works of J.C. Sager (1990) and M.T. Cabré (1998) may serve as excellent guides in this respect, offering a number of possible criteria according to which terms can be analysed. Instead of engaging in a wide-ranging discussion of the various approaches to classifying terms, in what follows only a few criteria are explored. The reason for zooming in on this particular group of criteria lies in the fact that they are specific to terms and are relevant for dictionary compilation.

One such term-specific classification has been suggested by J. Lukszyn and W. Zmarzer (2006: 24), who distinguish between quasi-terms and hypoterms. Both of these classes are similar in that they can be found in specialised texts, the natural environment of terms, thus making up part of specialised vocabulary. However, they differ with respect to their semantics and dynamics. As described by J. Lukszyn and W. Zmarzer (2006: 24):

> A quasi-term is as a general rule a general [language] word whose subject-field definition is derived from its [general] language meaning. A characteristic trait of quasi-terms is that the definitions of their respective concepts are continuously being sought, which manifests itself in dozens of multifarious definitions[8].

In keeping with this description, quasi-terms can be seen as occupying the borderland between general language words and terms, representing an intermediary moment in the life cycle of terms, one that occurs between the “general language word” and “term” phases. Of note here is the fact that general language words may be identical in form to quasi-terms and may also overlap in

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[8] “Quasi-termin jest to z reguły wyraz ogólny, którego definicję fachową wyprowadza się ze znaczenia językowego. Cechą charakterystyczną quasi-terminów jest to, że definicja odpowiednich pojęć jest permanentnie poszukiwana, co znajduje wyraz w dziesiątkach różnorodnych definicji”.

meaning with them, but this characteristic seems optional, albeit typical. The focus of the passage by J. Lukszyn and W. Zmarzer is decidedly placed on the second sentence, implying that the essential characteristic of a quasi-term is its unsettled definitions, representing the fuzziness of the underlying concept.

It can be argued that fields differ with respect to the degree to which their specialised vocabularies contain quasi-terms. In the case of logic or mathematics one might expect to find fewer quasi-terms than e.g. in linguistics or social sciences (for the latter see Sartori 1984), the reason for this phenomenon lying in the natures of the disciplines and their respective objects of investigation. However, even in mathematics, which is often credited with having a precise and rigorous language (e.g. Avigad 2007: 234), one may come across terms that tend to have more than one definition. *Natural number* and *trapezoid* can be cited here as apt examples (Usiskin et al. 2007). By contrast, it seems not uncommon for linguists to employ terms for which several definitions are available. This might explain the frequency with which linguists decide to explain the meaning of the terms that they refer to. If there were universally accepted definitions for them, the need for their discussion would be largely obviated.

Another class within specialised vocabulary is that of hypoterms. J. Lukszyn and W. Zmarzer (2006: 25) describe them as general language words whose linguistic properties undergo changes in specialised texts, which may involve losing (some of) their general language synonyms, modifying their stylistic value or their grammatical behaviour. A good case in point is the adjective *unstable*, which appears in both general and specialised texts. In the former, it typically evokes negative associations, witness the following two sentences: *Her friend seemed rather unstable* and *The situation in the country remains unstable*. However, in chemical or physical texts the word can be used neutrally, without the additional emotional charge. Moreover, general language synonyms such as *shaky*, *unpredictable* or *volatile* are unlikely to be good substitutes for *unstable* in physical or chemical texts.

Both quasi-terms and hypoterms are classes within specialised vocabulary that are different from terms proper. While they originate in general language vocabulary, they depart from it with respect to their grammatical and semantic properties. Of the two, it seems that quasi-terms are more dynamic as they can transform into terms proper, once consensus on their meaning is reached[9].

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[9] For cases where hypoterms can tranform into quasi-terms see Karpiński (2008: 45–46).

The distinction between different classes within specialised vocabulary is not only helpful in showing that there are different strata of specialised vocabulary with distinct properties but it can also shed some light on why the question *What is a term?* has yielded so many different answers to date. If the existence of different degrees of termhood is accepted, which is implied by the classes of hyponyms and quasi-terms, it is easier to understand the varying motivation behind setting the boundaries of what is understood by *term* (see Grucza 2008a: 177). This can be exemplified by referring to J.C. Sager's description of terms introduced in the previous section. It seems that what he refers to as words includes hypoterms in J. Lukszyn and W. Zmarzer's terminology. In turn, his terms seem to include both terms and quasi-terms, but he does not explicitly mention that there may be different degrees of exactness of reference, which provides the foundation for the term/quasi-term distinction made by J. Lukszyn and W. Zmarzer. Hence it can be concluded that J.C. Sager's definition seems to be motivated by the semantic shift occurring between words and terms. The recognition of termhood as a non-binary category can also be of assistance in understanding why some scholars used a definition of term that is even broader than that of J.C. Sager (see Pearson 1998: 12–21, Michta 2017: 232–234).

Finally, a note should be made of one more division whereby terms are subdived into theoretical terms and empirical terms[10] (Lukszyn and Zmarzer 2006: 30–35). Its basis is formed by the different natures of objects to which terms can refer. As suggested by their names, empirical terms refer to objects that are "experienced materially" while theoretical terms refer to "ideal objects derived by humans from a specific theoretical construct" (Lukszyn and Zmarzer 2006: 30). The authors offer a long list of the differences between these two classes, but all of them can be seen as stemming from the constrast between their semantics. According to their framework, while a theoretical term is embedded in a system of other terms that contribute to its meaning, it can exhibit semantic variability resulting from any changes in the respective theoretical basis. By contrast, empirical terms typically do not form systems of items which mutually define their meanings and they show greater semantic stability as the act of naming an empirical object tends to be a one-time event. An analysis of chemical terms is provided in section 1.5.

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[10] Similar distinctions have also been made within the philosophy of science (see e.g. Achinstein 1968: 157–201).

1.4. Chemistry as a branch of science

It can be argued that for any discipline the nature of its terminology is shaped by that discipline's object, methods and objectives. Before discussing features of chemical terminology, the subject of the next section, it is therefore a useful preliminary to first characterise chemistry as a discipline at some length and touch upon how it relates to other disciplines. Clearly, neither terminology nor linguistics for that matter can make any claims as to the disciplinary status of chemistry, as this is a matter that must be left for chemists to decide. However, the answer to the question of chemistry's place among other sciences is of direct relevance to terminologists who might want to distinguish chemical terms from other terms and in doing so they might have to be able to delineate chemistry from related disciplines.

The understanding of what chemistry is and what objectives it pursues has evolved over the centuries, mirroring the advances made in this discipline. This is attributable to the fact that major chemical discoveries have often necessitated a redefining of the object and aims of chemical endeavours. One such watershed event was the Chemical Revolution of the 18th century[11], which among other things encompassed the formulation of the law of conservation of mass and the replacement of the phlogiston theory with the oxygen theory of combustion (Cohen 2001: 231). A major factor driving the revolution was the work of A.L. Lavoisier. His seminal publication *Traité élémentaire de chimie* (1789) in many respects can be said to have ushered in a new epoch in the history of chemistry[12].

Changing attitudes to the scope of chemistry have been reflected in its definitions. For J. Black (1807: 11), chemistry was:

> the science or study of those effects and qualities of matter which are discovered by mixing bodies variously together, or applying them to one

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[11] The acceptance of R. Boyle's corpuscular theory, which posited a radical departure from the Aristotelian views of his contemporaries, was an important prelude to this revolution (Melsen 2004: 99–109).

[12] McEvoy (1988) makes a convincing argument for an appropriate representation of continuity and discontinuity in moments of scientific change. That, however, does not diminish the importance of the revolution. To quote Eddy, Mauskopf and Newman (2014: 6): "the primacy of the Chemical Revolution as the telos of eighteenth-century chemistry remained unchallenged".

> another with a view to mixture, and by exposing them to different degrees of heat, alone, or in mixture with one another, in order to enlarge our knowledge of nature, and to promote the useful arts.

When juxtaposed with L. Pauling's (1998: 1) understanding of chemistry as "the science of substances–their structure, their properties, and the reactions that change them into other substances", it is evident that J. Black's definition with its focus on the general concept of matter rather than the more specific concept of a substance and its limited repertoire of research methods represents an approach to chemistry that, understandably, only overlaps with what might be called modern views on chemistry.

A definition similar to that of L. Pauling has been formulated by T.L. Brown et al. (2012: 3) "chemistry is the study matter and the changes that matter undergoes". In particular, chemists seek to examine the composition and properties of matter and understand how matter changes, one of their aims being to find the link between the structure of matter and its properties, which will enable them to predict the properties of forms of matter that are currently unknown.

Broad as the definitions by and L. Pauling and T.L. Brown et al. may seem, they mirror the wide spectrum of chemists' interests. As chemistry is such a vast discipline, it can be divided into four major subdisciplines (Sienko and Plane 2002: 19):

1) analytical chemistry involves the analysis of material samples, so that their composition and structure can be determined (qualitative analysis) and the amount of a given element or a compound present in a sample be established (quantitative analysis);
2) physical chemistry is the study of the physical processes that underlie chemical systems and reactions. In particular, reaction rates, energy changes accompanying reactions, and the effects of applying current to a solution are of interest to physical chemists;
3) inorganic chemistry deals with the reactions and properties of all elements and compounds excluding the vast majority of carbon compounds;
4) organic chemistry deals with the properties and reactions of most carbon compounds.

The above classic subdisciplines of chemistry seem, however, to still be extremely broad given the present-day degree of specialisation among chemists.

With approximately 500 000 articles on chemistry published every year (Hoffmann 2001: V), it has become almost impossible for any chemist to be fully conversant with the latest discoveries that are made within such broadly-defined fields of science. Consequently, new, more specialised subfields of chemistry have already emerged as a result of chemical advances. Coupled with a proliferation of inter- and transdisciplinary fields whose names included the word *chemistry*, there is now a plethora of names such as biochemistry, cosmochemistry, electrochemistry, femtochemistry, geochemistry, photochemistry, polymer chemistry, and thermochemistry, to name but a few. A plausible explanation of why chemists so often encroach on the territory of other fields is provided by C. Reinhardt when he writes "research is problem-defined and is not confined to a single discipline" (Reinhardt 2001: 3). The existence of many chemical subdisciplines, which enjoy a varying degree of independence, provides justification for the widespread use of the name *chemical sciences*, which appears for example in the title of a book edited by C. Reinhardt: *Chemical Sciences in the 20th Century: Bridging Boundaries*.

Chemistry is sometimes referred to as the "central science". This expression appears for example in the title of the widely acclaimed textbook by T.L. Brown et al. *Chemistry: The Central Science*, which was many a time consulted when the practical part of the present thesis was being compiled. But what are the reasons that prompt some scientists to label chemistry the central science?

The authors of *Chemistry: The Central Science* offer a brief answer to this question. They argue that chemistry is the central science since "many subjects share an essential tie to chemistry" (Brown et al. 2012: 5). Indeed, chemistry constitutes an important part of the curriculum of agriculture, biology, engineering, pharmacy and many other fields. A similar statement can, however, be made with respect to mathematics as many subjects seem to share a tie to it, or physics. In a recent article entitled *Is Chemistry 'The Central Science'* A.T. Balaban and D.J. Klein (2006) approached the question of the centrality of chemistry from an empirical angle. By analysing cocitations, curricular correlations, and historical dependences, they developed a framework for the partial ordering of the sciences, one which can be illustrated by means of the diagram below:

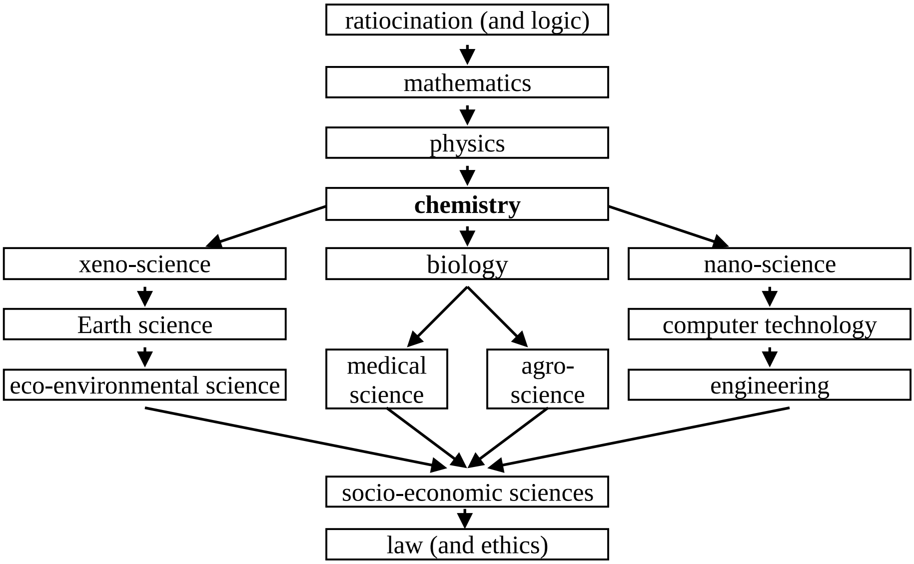

Fig. 2. Partial ordering of the sciences (adapted from Balaban and Klein 2006: 620)

Each science that is higher in the diagram provides a framework for those that are lower. Thus ratiocination (and logic) provides the framework for mathematics, which provides the framework for physics, which in turn provides the framework for chemistry. The sciences that rely on the framework provided by chemistry include xeno-science (cosmology, astronomy, planetary science), biology, and nano-science. The diagram can be interpreted to imply that chemistry occupies an important place in it. It can be seen as central, since it is "at the location where significant branching begins" (Balaban and Klein 2006: 622).

The hierarchy of sciences proposed by A.T. Balaban and D.J. Klein appears to have significant implications for terminology and terminography since it can be used to account for the fact that mathematical and especially physical terms are not infrequent in chemical texts. As mathematics forms the framework for physics, which in turn forms the framework for chemistry, the presence of terms from these parent disciplines in chemical texts can hardly be surprising. This holds true especially for texts from physical chemistry, in which physical terms are particularly frequent. By the same token, one can expect that texts devoted to xeno-science, biology, or nano-science are likely to contain chemical terms.

One may argue that the presence of terms from other disciplines in a given text may be yet another criterion for developing an ordering of the sciences. A high percentage of such terms might indicate that the discipline in question is dependent on the discipline(s) whose terms appear frequently in texts of that discipline. If no terms from other disciplines occur, the discipline may be independent of other disciplines. By analysing texts belonging to different disciplines, one may arrive at a new ordering of the sciences. However, this tentative hypothesis needs empirical verification.

The decision as to whether a particular dictionary of chemistry should include terms that fall at the intersection of chemistry and other disciplines (e.g. mathematics or physics) rests with the compiler of the dictionary, who should be aware of the inter- and transdisciplinary nature of many facets of chemical research, which manifests itself in the presence of terms from disciplines other than chemistry in chemical texts. The decision, whether positive or negative, must reflect the needs of the prospective users of the dictionary.

1.5. Selected features of chemical terminology

The terminology of chemistry can be described as being rich, varied and, to a significant portion of society at large, impenetrable. It has a *sui generis* character that is closely linked to the nature of the subject field it describes, as will be argued below.

Perhaps the most salient feature of chemical terms is to be found in their semantics, which contributes to their specificity. An important aspect of this can be seen in the change in the meaning potential of the same linguistic form depending on whether it is used in a chemical text (and in a chemical context) or in a general text (and in a general context). Before discussing this in greater detail, it is worth mentioning that terms, be they chemical or not, can be divided into those whose linguistic form is part of general vocabulary and those whose linguistic form is part of terminology only. From a semantic point of view, the former category can be subdivided into two groups according to whether

1) the meaning expressed by a linguistic form as used in general vocabulary overlaps with that used in terminology; or
2) the meaning expressed by a linguistic form as used in general vocabulary is separate from its terminological meaning.

One example illustrating the first case is furnished by the word *salt*, which is frequent in chemical and general texts alike and can be said to constitute part of general vocabulary. The online *Macmillan Dictionary*, which can be classified as a learner's dictionary and thus "should reflect the average speaker's linguistic competence – no more, no less" (Hausmann – Gorbahn 1989: 44), provides the following description of its meaning (MED Online 2018)[13]:

> a white substance that is often added to food before or after cooking to improve its flavour. Salt is dug from the ground, or produced from sea water.

Another name for the substance referred to in that description is common salt. From a chemical point of view, it consists of sodium chloride, or NaCl[14]. In chemistry, however, the word *salt* is interpreted differently. The *Oxford Dictionary of Chemistry* (Daintith 2008) states that it is:

> A compound formed by reaction of an acid with a base, in which the hydrogen of the acid has been replaced by metal or other positive ions.

Although written in contrasting styles, the two definitions imply some clear overlap between the extensions of *salt* as used in general texts and in chemical texts. While *salt* appears in general texts to refer to a specific substance (which chemists might describe as sodium chloride, NaCl), the word in a chemical text is reserved for a broad category of compounds, including sodium chloride and numerous others that those that do not contain sodium or chlorine, such as ammonium nitrate (NH_4NO_3).

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[13] The same dictionary also features this definition: "a chemical substance formed from an acid" and labels it "chemistry". The fact that this strictly chemical sense has found its way into the dictionary might suggest that the term may also appear in general texts, albeit infrequently. Be that as it may, the culinary sense is the primary one. While the inclusion of the strictly chemical sense is to be applauded, it is unfortunate that the definition suffers from significant imprecision. Countless substances can be formed from an acid (for example oxides) but that does not make them salts.

[14] Strictly speaking, the white substance referred to in the definition may contain more than just sodium chloride, e.g. iodine, making it chemically impure. Such considerations may be relevant for chemistry but are generally insignificant in everyday communication. On another level, equating the meaning of *salt* with sodium chloride, which L. Bloomfield (1933: 139) suggested, runs into semantic problems, which A. Wierzbicka (1985: 193) attributes to a failure to distinguish between scientific knowledge and folk categorisation.

The word *mole*, which can be said to form part of general vocabulary and is also used as a term, exemplifies a case where the meaning of the term shows no overlap with that of the word mole as used in general texts. The previously quoted *Macmillan Dictionary* (MED Online 2018) contains five definitions of this word that may be summarised as:

1) a small animal
2) a brown lump/spot on the skin
3) someone who gives information
4) a wall defending against waves
5) a unit of molecules

The fifth definition is labelled “science”, which may be taken to mean that it does not form part of general vocabulary. If this definition is excluded, the remaining four share no links to the sense which can be defined as “the SI unit of amount of substance. It is equal to the amount of substance that contains as many elementary units as there are atoms in 0.012 kg of carbon-12” (Daintith 2008: 357).

Complementary to the two classes of terms discussed earlier is the third one which comprises all those terms whose linguistic form does not belong to general vocabulary. In terms of its sheer size, this group can be characterised as by far the largest. Terms such as *comproportionation, isomer, ligand, moiety, superoxide*, *titration*, *Wurtz reaction* and *zwitterion* can be cited as good representatives of this class, as can most names of individual substances (both trivial and systematic ones, of which there are plenty).

Mierzwicki (1988: 7) points out that chemical terminology consists mainly of the names of chemical elements, chemical compounds and their classes; the names of chemical reactions, chemical procedures, and chemical apparatus. By way of example, below are three terms for each of these types:

1) chemical elements (*hydrogen, iron, oxygen*)
2) chemical compounds (*benzene*, *carbon dioxide*, *potassium bromide*)
3) classes of chemical compounds (*alkanes*, *oxides*, *salts*)
4) chemical reactions (*decomposition reaction, single replacement reaction, synthesis reaction*)
5) chemical procedures (*distillation, extraction, titration*)
6) chemical apparatus (*beaker*, *burete*, *funnel*)

All of these types seem to dovetail nicely with the definitions of chemistry discussed earlier. Examining the properties of substances as well as the changes that they undergo has clear linguistic implications as chemists need to be able to differentiate between individual substances and be able to designate each of them differently. The same can be claimed with respect to the names of chemical reactions as well as of groups of elements and compounds, which allow chemists to organise their knowledge of substances and compounds on the basis of their shared characteristics. Finally, the need for names for chemical procedures and chemical apparatus stems from the fact that chemistry is a science with a rich repertoire of its own methods and tools.

Unlike terms in many other fields, chemical terms frequently undergo standardisation, a process consisting “of users reaching ‘public’ agreement to adopt a given term for use in specific circumstances” (Sager 1990: 114). This has considerable benefits as it can bring greater clarity both with respect to what a given language form means but also how a given concept is best expressed. If there is agreement that experts use standardised terms (as regards their form and meaning), then the need to negotiate terminology in publications can be minimised. In the case of chemistry, the task of standardising its terminology falls to the International Union of Pure and Applied Chemistry (IUPAC), which publishes its recommendations on terminology, nomenclature and symbols in the journal *Pure and Applied Chemistry* and also in books[15]. The cover of each of these books is assigned a different colour. For instance, red has been used for inorganic, blue for organic, green for physical, and orange for analytical chemistry, which explains the origin of the names *Red Book*, *Blue Book*, *Green Book*, *Orange Book*, etc., which are in frequent use among chemists. As IUPAC recommendations are originally written in English, relevant national bodies adapt them to meet the requirements of national languages. In Poland, this function is held by the Polish Chemical Society (Polskie Towarzystwo Chemiczne), in particular its Chemical Terminology Committee (Komisja Terminologii Chemicznej)[16].

Since substances are at the heart of chemical inquiry and their terminology displays some unique features, it is worthwhile to focus on their designations[17]. Two common ways of designating chemical substances that are discussed here are formulae and chemical names. In chemical formulae, symbols are used to indicate the elements that make up a particular substance. Different

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[15] https://iupac.org/what-we-do/recommendations/ (accessed 25.12.2018).

[16] http://cryst.p.lodz.pl/KTCh/ (accessed 25.12.2018).

[17] Some of the comments that follow were also made in an earlier publication unavailable in English (Michta 2008).

types of formulae can be used depending on intended level of communicational accuracy. An empirical formula reflects the relative proportions of atoms in a compound. This does not have to coincide with the actual composition of molecules, in which case a molecular formula may be preferable, provided that it has been established. If chemists want to include information about how atoms are grouped in space, they can resort to a structural formula (Brown et al. 2012: 53–54). Hydrogen peroxide can be used to illustrate this. Its empirical formula is HO, which means that it consists of hydrogen atoms (designated by the letter H) and oxygen atoms (designated by the letter O) with a ration of 1:1. Its molecular formula is H_2O_2, which indicates that actual molecules of it consist of two atoms of oxygen and two of hydrogen. Finally, its structural formula is HOOH (Brown et al. 2012: 54), which suggests that the order in which individual atoms are spaced is hydrogen, oxygen, oxygen, and hydrogen. Chemical formulae have considerable advantages: brevity (when compared to systematic names), the ability to convey information about the composition of a substance (as do systematic names), and supranational character, as the symbols they use are not specific to a single language. This makes them well suited for use in chemical equations but some of them can also be used in spoken communication.

Another way of designating a substance is to use its chemical name. IUPAC defines the aims of chemical nomenclature in the following manner (Connelly et al. 2005: 3):

> The primary aim of chemical nomenclature is to provide methodology for assigning descriptors (names and formulae) to chemical species so that they can be identified without ambiguity, thereby facilitating communication. A subsidiary aim is to achieve standardization.

Back when the number of known substances was limited, many (al)chemists invented their own names for every new compound. However, with the development of chemistry as a science it became essential to develop a system of rules which could be used to assign names to substances. The first such system was developed by Guyton de Morveau in 1782 (Connelly et al. 2005: 2). Subsequent systems sought to encompass the growing number of chemical substances and reflect with increasing precision the different structural arrangements of atoms in compounds as these continued to be discovered. Reflecting a pressing need to devise a system of nomenclature that could meet with international recognition, the Geneva conference of 1882 was a milestone event and it laid the groundwork for a unified system of rules with regard to organic compounds (Thurlow 1998: 103). The task of revising and expanding chemical nomenclature then fell to the International Union of Pure and Applied Chemistry (IUPAC), which was formed in 1919 (Thurlow 1998: 103). The work of the IUPAC continues to this day.

There are several features that together make IUPAC chemical nomenclature unique. One of them is its systematic character, which means a that is based on an elaborate set of rules that can be used to automatically assign an unambigous name to a substance. If ambiguity in identifying chemical species is to be avoided, then one can expect that every chemical name should correspond to one chemical species only. However, the converse relation does not always hold, i.e. it is possible for a single substance to be designated by several different names (Connelly et al. 2005: 5). This does indeed happen as IUPAC nomenclature contains several systems that sometimes can be applied to name compounds. As far as inorganic chemistry is concerned, three systems merit attention, viz. compositional, substitutive, and additive nomenclature (Connelly et al. 2005: 5). Different systems can sometimes be used to name the same compound, which leads to the existence of many names for just one substance. An offshot of the systematic character of IUPAC nomenclature is the fact that the present rules of chemical nomenclature may yield names for many compounds that to date have not even been identified. Such flexibility in the system is clearly an asset. Given the current rate at which new compounds are discovered, having a practical system that can instantly produce a name for a compound is an absolute necessity. However, developing such a system is fraught with difficulty. In order to realise the enormity of the task that members of this organization have undertaken over the years, one has to bear in mind the gargantuan number of organic and inorganic substances that have been identified to date. Based on data provided by the Chemical Abstract Service on 14 October 2018, this amounted to 144 million substances (CAS 2018). Developing a system capable of encompassing such a multitude of substances is a complex process.

Apart from their sheer number, the variety of chemical substances magnifies the difficulty of the task. This is why the name of a substance may comprise a host of different structural components. In the case of inorganic chemistry these can include: element name roots, multiplicative prefixes, prefixes indicating atoms or groups, suffixes indicating charge, names and endings denoting parent compounds, suffixes indicating characteristic substituent groups, infixes, locants, descriptors, and punctuation (Connelly et al. 2005: 5). Consequently, no chemist worth their salt will bat an eyelid when they see a chemical name featuring parentheses, hyphens, dots, colons, semicolons, Arabic and Roman numerals, Greek letters, asterisks or primes, whose use is detailed in IUPAC books. An example of a compound name which include elements of different types is bis(μ-diphenylphosphanido)bis(dinitrosyliron)[18], which is a coordination compound whose formula is $[\{Fe(NO)_2\}_2(\mu\text{-}PPh_2)_2]$. The impressive productivity of IUPAC rules can be seen in the case of titin. This protein, found in striated muscle tissues, has the following molecular formula $C_{132983}H_{211861}N_{36149}O_{40883}S_{693}$, which means that a single molecule consists of 422 569 atoms, and its systematic name consists of 189,819 letters, thus being the longest name given according to IUPAC rules (McCulloch 2009). Such systematic names are anything but practical, which is why titin and other complex substances use trivial names which can be much more convenient, even though they may convey no information as to the composition of the substance in question.

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[18] A interesting discussion of morphological properties of chemical names has been offered by A. Sulich (2013).

Chapter 2

Terminographic Foundations of the Model

2.1. Terminography versus lexicography

While the previous chapter centred on what the intended model of a systematic dictionary should represent, i.e. chemical terminology, the present one proceeds to focus on the object used to model said terminology on, i.e. a terminological dictionary. Before this concept is introduced, it would be a useful preliminary to return to a term that has already been mentioned in Chapter 1, namely – *terminography*.

The term first appeared in Chapter 1 in the context of discussing the polysemy of *terminology*, which in its second meaning distinguished by B. de Bessé, B. Nkwenti-Azeh and J.C. Sager (1997: 154), viz. “The set of practices and methods used for the collection, description, and presentation of terms” is sometimes used interchangeably with *terminography*. Other synonyms (or near-synonyms) include *terminological lexicography*, *specialised lexicography*, *LSP lexicography* and *practical terminology* (Gajda 1990, Zmarzer 1991, Bergenholtz and Tarp 1995, Rey 1995, Hartmann and James 1998).

Terminography may also be defined as “A complex of activities concerned with the design, compilation, use and evaluation of TERMINOLOGICAL DICTIONARIES” (Hartmann and James 1998: 139). The term was coined by A. Rey by analogy with *lexicography* and the two clearly share a common foundation – “the compilation and ordering of data and semantic analysis” (1995: 129). However, as its linguistic form suggests, it differs from lexicography through its (exclusive) focus on terms. Since *term* can be understood differently, as shown in Section 1.2, so too can the scope of terminography vary as a result. Several scholars (Rey 1995: 129–133, Hartmann and James 1998: 139, Antia 2005) have attempted to foreground the differences between the two fields. R.R.K. Hartmann and G. James (1998: 139) propose a list based on eight different criteria that can be used to distinguish between general lexicography and terminological terminography, which is included below in an adapted form (the text to the left of the slash refers to general lexicography; that to the right to terminological lexicography):

1. orientation of compiling (from word to sense / from concept to term)
2. compiling method (small-scale database / computational database)
3. scope (general vocabulary / technical terminology)
4. corpus data used (non-specialist texts / specialist texts)
5. definition style (linguistic / encyclopaedic)
6. functionality (multi-purpose general users / special-purpose expert users)
7. arrangement of macrostructure (script-based word-list / thematic term list)
8. overall aim (explanation of meanings / standardisation of terms).

Such juxtapositions may be succinct and yet they are highly informative. Their interpretation requires a good deal of caution, however. The compiling method as a criterion has lost its currency as a valid criterion due to the widespread use of computers in modern lexicographical and terminographical undertakings of all kinds. As regards the remaining criteria, they continue to be relevant but their power to discriminate is not absolute. Upon closer inspection, for every criterion an example can be cited that seems to contradict its generality. This fact inevitably leads to the conclusion that all these differences are ones of degree and that they at best correspond to what might be described as prototypical lexicographic and terminographic works.

If the distinctions between general lexicography and terminography, on the one hand, and general lexicology and terminology on the other are considered, the relationships between them can be depicted by means of the diagram below:

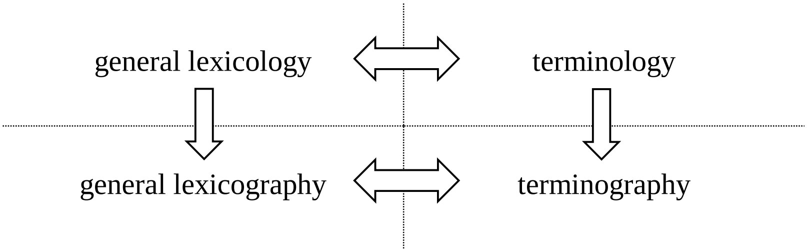

Fig. 3. Relationships between lexicology, lexicography, terminology, and terminography

The vertical line indicates the border between general lexicology and terminology as well as that between general lexicography and terminography. Here the concept of *term* is key. The fields on the left do not primarily deal with terms. The opposite can be claimed with respect to the fields on the right. The line is dotted, which is intended to show that the borderline between terms and general language words is fuzzy[19] (Grucza 2008b: 187), hence general lexicology and terminology as well as general lexicography and terminography may overlap to a certain degree. As regards the line between general lexicography and terminography, it can be viewed more specifically as being determined by the concepts of a *general (language) dictionary* and *terminological dictionary* or, even more inclusively, a *general lexicographic work (of reference)* and *terminographic work (of reference)*. The horizontal line indicates the borderline between general lexicology and general lexicography as well as terminology and terminography. It is dotted to underline the fact that general lexicology and general lexicography, as well as terminology and terminography, share a keen interest in general language words and terms respectively. The arrows in the diagram are intended to show how individual fields may benefit from one another. For general lexicology / terminology and general lexicography / terminography, reciprocity can often be claimed since the methods of analysis and their results in each field may stimulate developments in the other in each field. For general lexicology / general lexicography and terminology / terminography, it seems that the relationship is decidedly lopsided. While some frameworks that have developed within general lexicology / terminology may be successfully adopted in general lexicography / terminography, the reverse is less likely. Dictionaries may serve as source material in lexicological / terminological studies and new approaches to general lexicology / terminology may be developed as part of the dictionary compilation process. However, in both these cases the lexicological / terminological aspect seems to embedded in the nature of the project from the get-go.

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[19] Roughly speaking, the line can also be interpreted as corresponding to the division between general language and specialised language. Since there is no clear-cut bordeline between the two (Grucza 2008a: 142), the dotted line is justified here as well.

2.2. Terminological dictionaries

As stated in the preceding section, the focal point of terminography is terminological dictionaries. Following I. Burkhanov (2010: 240), a *terminological dictionary* can de defined as "a *reference work* intended to describe specialized *terminology* (1) of a particular subject field". Descriptions like this are not unusual. What is implied in them is that the meaning of *terminological dictionary* is contingent on that of *terminology*, which by extension is contingent on that of *term*. The point might seem obvious but it bears repeating as it explains why *terminological dictionary* is sometimes interpreted differently. When for example R.R.K. Hartmann and G. James (1998: 140) state that it is "about the language (especially the VOCABULARY) of a specialist field", it might be because they view terminology in a specific way.

A terminological dictionary can be conveniently conceived of as first and foremost a specialised text that is produced by a terminographer and received by a user. A number of factors set terminological dictionaries apart from other specialised texts. One of the particularly salient ones is concerned with the inherently metalinguistic nature of terminological dictionaries. Regardless of the functions that they are intended to serve, be it native-language production, native-language reception, foreign-language production, foreign-language reception, translation into the foreign language, translation from the foreign language (Bergenholtz and Tarp 1995: 24) or some other function, terminological dictionaries are texts about certain aspects of language and they are typically intended to model them (Michta 2014). Unlike many other specialised texts, terminological dictionaries, while being autonomous themselves, are strongly dependent on other specialised texts, which are typically written by subject-field specialists. In other words, terminological dictionaries presuppose the existence of specialised texts. Bearing this in mind, instead of adopting a simplistic perspective on terminological dictionaries whereby they are perceived as specialised texts produced by terminographers and received by a target user, it seems justified to advance the view that additional elements need to be included as well: specialised texts and their authors, i.e. subject-field specialists. The following flow chart may be proposed to illustrate the communicative model of terminological dictionaries[20].

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[20] The model is akin to that of translation (see Kielar 2003).

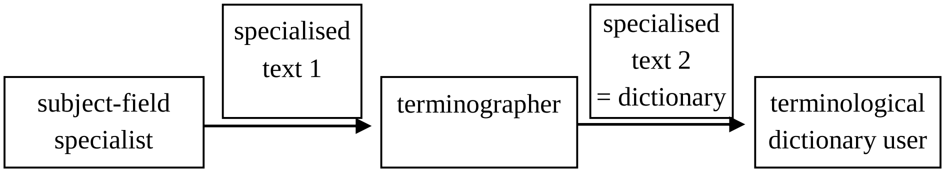

Fig. 4. The terminological dictionary as a specialised text
in the process of specialised communication

Although the singular has been used in the diagram, it cannot be assumed that only two specialised texts and three persons are involved. In practice, usually collections of specialised texts (corpora) produced by a number of specialists are used while compiling a dictionary so that the idiosyncratic features of specialised texts produced by individual specialists can be eliminated. Also, it is not uncommon to find terminological dictionaries compiled by a team of terminographers. Depending on the specifics of an individual dictionary project, the model could be extended to include additional elements.

2.3. Selected principles of compiling terminological dictionaries

Compiling dictionaries is a multifaceted process, as even a cursory glance through a textbook on dictionary-making will reveal (e.g. Atkins and Rundell 2008). While acknowledging the complexity of the matter, J. Lukszyn and W. Zmarzer (2006: 134) propose distilling the various principles found in literature down to the following three:

1) the principle of appropriately limiting the body of terms in the dictionary
2) the principle of systematising terminology in the dictionary
3) the principle of the interlinguistic harmonisation of terminology in the dictionary.

The first principle involves a number of stages. First, a corpus of texts to be analysed needs to be chosen. A corpus can be defined as a “body or collection of linguistic data” (Burkhanov 2010: 49). In its narrower meaning, a corpus is (Sinclair 2005: 16):

> a collection of pieces of language text in electronic form, selected according to external criteria to represent, as far as possible, a language or language variety as a source of data for linguistic research.

Not all corpora are created equal. Consequently, despite their growing number (some of which are publicly available), selecting the right corpus for dictionary compilation is crucial. Among the criteria that are worth considering are (Atkins and Rundell 2008: 57–76) its size and content (described in terms of attributes such as language, time, mode, medium, domain). Provided that the terminographer has access to the right corpus, they can proceed to process it. Failing that, a new corpus will have to be compiled. For many fields and languages, large, freely available and reliable corpora are yet to be created, so the task of designing and creating a corpus may fall to terminographers. In such cases even more careful consideration may be required. As argued by L. Bowker (2003: 161–162):

> Care must be taken to evaluate the quality and appropriateness of the texts to be included in the corpus as well as to ensure that the range of texts selected will provide adequate coverage of the field in question.

One cannot but agree with her. A haphazardly collected potpourri of specialised texts can only translate into a failed terminological dictionary that is of little to no use to the prospective user.

A major strength of using corpora is that they help to objectify the process of dictionary compilation (Atkins and Rundell 2008: 46–47) as well as expedite it (Landau 2001: 323). This can clearly be seen when terms are selected for inclusion in a dictionary as corpora provide opportunities for quickly calculating the frequency of linguistic forms, thus helping judgments to be made as to which forms merit inclusion in the dictionary and which do not. However, the benefits of corpora go beyond compiling the entry list, as they can prove equally convenient when searching for collocations of a given term, examples of its use, and also its definitions (see Łukasik 2007b, Michta 2007a, 2007b).

The second principle requires terminographers to develop rules for systematically presenting terminology in a dictionary and implementing them. Depending on the specific features of the subject field as well as target users, different systematisation techniques may be required. In this sense systematisation mostly concerns the arrangement of entries (the macrostructure of a dictionary) but also determines the structure of an entry (the microstructure of the dictionary) as well as the type of definition that is most suitable for different classes of terms included in the dictionary (Lukszyn and Zmarzer 2006: 134–136). The main ways of arranging entries within a dictionary are as follows (cf. Burkhanov 1999, Zwierzchoń 2001: 124–136):

1) external arrangement
2) formal arrangement
3) ideographic arrangement

The external type of arrangement means that entries are arranged according to an external object, e.g. another text. In the Middle Ages, for instance, the Bible would serve as a benchmark for the arrangement of entries. In other words, the entries within a dictionary appeared in the order in which the respective words appeared in the Bible (Miodunka1989: 25). This external arrangement has survived until today, e.g. in a slightly different incarnation in frequency dictionaries.

The formal type of arrangement means that entries are arranged according to their formal characteristics. One of the most commonly known examples of this type of arrangement is the alphabetical arrangement. Entries can be alphabetised from left to right or vice versa, but the latter method is rarely applied, particularly in terminological dictionaries, due to the fact that very few users need such ordering. The use of alphabetical arrangement is so widespread that in modern English usage *dictionary order* and *alphabetical order* are synonymous (Jackson 2002: 145). Perhaps the most apparent advantage of alphabetical arrangement is the fact that the order of letters in the alphabet is widely known to the speakers of a language. Hence they can easily find an unknown word in a dictionary. Alphabetical arrangement has, however, one important drawback, namely that words are treated in isolation, so words that are related through their meaning are scattered throughout the dictionary (Jackson 2002: 145–147).

The third type of arrangement, the ideographic arrangement, means that entries are arranged according to their meanings (Burkhanov 1999: 108–112). This arrangement presupposes a classification of a given lexicon. Words that are similar in meaning will appear in the same category. This type of arrangement allows its users to familiarise themselves with a whole class of related words and in the case of terminological dictionaries can be said to reveal the structure of specialised knowledge. Consequently, it is particularly recommended for teaching purposes. Ideographic dictionaries exist as far as both general language dictionaries and terminological dictionaries are concerned. A recurrent problem in compiling such dictionaries is the development of a classification system that would cover all words in a lexicon. This stage, i.e. classification development, renders the task extremely arduous. Moreover, as there is no universal classification system, different dictionaries follow different rules of classification (Burkhanov 1999: 109–110). It might seem that compiling an ideographic dictionary of terminology would require significantly less effort than one of general vocabulary but even classifying specialised vocabulary items presents its own problems (Zmarzer 2005: 18). Ideographic dictionaries pose challenges for users as well. Before finding a word in the main part of a dictionary, they often have to consult the index and find the category to which the word belongs. Obviously, this drawback relates only to paper dictionaries.

The principle of systematisation, as proposed by Lukszyn and Zmarzer (2006: 134–136), also extends to assigning particular definition types to individual classes of terms, establishing semantic relationships between a given term and other terms and also designing the structure of an entry (its microstructure). Drawing on the long-standing tradition of lexicography, terminographers may make use of a number of different entry components, which may carry information about (Atkins and Rundell 2008: 201–244): navigating the entry, the lemma headword, meaning in monolingual dictionaries, meaning and translation in bilinguals, sense indicators, grammar, contexts, vocabulary types, usage, other lemmas, and with some additional components possible in electronic dictionaries. Deciding what types of information to include in the entries is one thing, ordering them in a systematic way throughout the whole dictionary is another. Since dictionaries cannot account for all kinds of detailed information about the lemmata[21], choices have to be made as to what information types to include and how detailed their description should be. These can be decided on the basis of user needs but also the nature of the terminology to be presented in the dictionary.

Finally, the principle of interlinguistic harmonisation of terminology in the dictionary requires terminographers to compare terms from at least two languages with the view of establishing their mutual equivalence (Kielar 2001: 144; Lukszyn and Zmarzer 2006: 141–142). Because of its focus on at least two languages, the principle is primarily relevant for bilingual and multilingual

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[21] As aptly noted by L.V. Shcherba (1995: 328), "each word that is the least bit complex should really be the subject of a scholarly monograph".

dictionaries but it can also be applied to the compilation of certain monolingual dictionaries, if these are translations (or adaptations) of dictionaries originally written in a different language or they provide information on the similarities and differences between related terms in at least two languages. Ideally, full equivalence exists between two terms from two languages, in which case including the equivalent in a dictionary entry is a straightforward matter. In the event that this ideal condition is not met, there needs to be a principled policy as to how such cases are handled. For example, if there is no naturally occurring equivalent for a given term, the dictionary compiler may decide to propose an equivalent or refrain from including any equivalent (Kielar 2001: 144), thus suggesting that the target language does not have a term to express the pertinent concept. Revealing conceptual mismatches between terms in two languages, or in extreme cases terminological lacunae (or terminological gaps), not only provides the user with important linguistic information but it can stimulate the development of terminology in the target language as well as further the evolution of specialised knowledge (Zmarzer 1991: 127).

2.4. Systematic dictionary as a dictionary type

Specialised dictionaries can be classified according to a number of criteria (see Zmarzer 2004). Since the focus of the present book is to develop a model of a systematic dictionary, elucidating the characteristics of this particular type of lexicographical work is indispensable, even more so since it has received little scholarly attention. The description *systematic dictionary* is hardly ever mentioned in lexicographic literature, a notable exception being I. Burkhanov (1999, 2010). The phrase is not particularly common in the titles of actual dictionaries either. According to a survey of existing English-Polish specialised dictionaries published between 1990 and 2006 (Łukasik 2007a), not a single dictionary included *systematic dictionary* in its title.

Some attempt at describing systematic dictionaries has been made in the *Dictionary of Lexicography* by R.R.K Hartmann and G. James (1998). Its entry for *systematic dictionary* redirects the reader to *onomasiological dictionary,* which is defined as “A type of REFERENCE WORK which presents words or phrases as expressions of semantically linked CONCEPTS, which may be meanings, ideas, notions, word families and similar relationships” (Hartmann and James 1998: 102). No distinction is made here between systematic dictionaries on the one hand and onomasiological dictionaries on the other in the remaining part of the entry. This reflects a common tendency whereby these two terms, as well as many others denoting dictionaries with a semantic macrostructure, are to a large extent used interchangeably (Michta 2012: 166). I. Burkhanov (2010: 237), however, also includes a more restrictive definition of *systematic dictionary*, stating that the hallmark of such lexicographic works is the presence of a classificatory scheme which is based on the semantic relations between the lexical units presented in the dictionary. *The Systematic Dictionary of English Verbs* edited by Z.N. Verdieva (1978) can be cited as a good example here. Writing specifically on terminological dictionaries, J. Lukszyn and W. Zmarzer (2006: 153) describe the main characteristics of systematic dictionaries in that context in the following way:

> In the systematic dictionary, the term is treated as a quantum of knowledge captured in the dynamics of its development. Therefore, an appropriate categorisation of terms is established, one based on the conceptual derivation of the individual components of a coherent terminological system[22].

A pivotal feature of this approach is that it relies heavily on classifying terms on the basis of their concepts. From the point of view of the dictionary compilation process, this has both practical and theoretical consequences. Since in the case of systematic dictionaries the additional requirement of term classification has to be met, this involves an additional task, which may lengthen the dictionary compilation process. More important, however, is the question of what criteria are to be used while classifying terms on the basis of their concepts. Various approaches to concept classification have been proposed; however, they are not necessarily well suited for terminological purposes (Sager 1990: 27). In the passage quoted earlier, J. Lukszyn and W. Zmarzer invoke conceptual derivation as the basis for term categorisation. Since the references to this term in literature are sparse, it is worth discussing it in some detail.

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[22] "W słowniku systemowym termin traktowany jest jako quantum wiedzy specjalistycznej ujętej w dynamice rozwoju. W związku z tym ustala się odpowiednia kategoryzacja terminów, która opiera się na pochodności konceptualnej poszczególnych komponentów spójnego systemu terminologicznego".

The idea of conceptual derivation is predicated on the assumption that the concepts of terms exhibit varying levels of complexity, which allow these concepts to be divided into classes. The simplest division could encompass two opposing classes: primary terms and derivative terms. For two related terms T_1 and T_2, T_2 is said to be a derivative term with respect to term T_1 if T_2 presupposes T_1[23]. In turn, T_1 is said to be the primary term with respect to T_2. Two terms from the field of physics will illustrate this well. *Length* and *metre* are undoubtedly closely related. The latter can be defined as ‘the base unit of length in the International System of Units’. This wording presupposes that *length* is a concept that is already known and thus *metre* can be said to be conceptually derived from *length*. The reverse, however, does not apply. While one might suggest that *length* be defined as ‘a base quantity of which metre is the base unit in the International System of Units’, such a formulation would lead to circularity between this definition and that of *metre*. Since these two definitions cannot co-exist together, one of them needs to override the other one. Here, only ‘the base unit of length in the International System of Units’ can be described as reflecting defining practice in physics and its internal logic. In a general case, the question of which definition should be prioritised is best answered on the basis of how a given term is defined by subject-field experts as each field has its own order in which new terms are defined in terms of already existing ones.

A more fine-grained distinction than that between primary terms and derivative terms has been offered and expounded by J. Lukszyn and W. Zmarzer (Lukszyn 2007: 61, Lukszyn and Zmarzer 2006: 34–35) and the remainder of this paragraph summarises their views. Their typology includes four main classes: primary terms, first-order derivative terms, second-order derivative terms, and key terms. However, derivative terms of higher orders, i.e. third-order and fourth-order derivative terms, etc. are also possible. Primary terms are limited in number and their aggregate constitutes the conceptual basis for a given terminological lexicon. First-order derivative terms can be conceptually derived from primary terms. Consequently, this class of terms contains more elements than the class of primary terms. As a general rule, they are stable and their meaning is clearly defined since their dependence on primary terms is of a direct nature (Lukszyn 2007: 61). Second-order derivative terms can be conceptually derived from first-order

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[23] Conceptual derivation can also be described in terms of conceptual complexity, with derivative terms being more complex than their primary terms.

derivative terms. Thus, one can claim that for a given discipline, there exist more second-order derivative terms than first-order ones (Lukszyn and Zmarzer 2006: 154). This statement holds true as long as the discipline under consideration is well-established. The last category of terms – key terms – serves to govern particular series of derivative terms and their number is frequently low.

J. Lukszyn and W. Zmarzer's proposal constitutes a promising research tool for terminology and terminography. Particularly valuable in this context is the idea of derivation order, which can be employed to arrive at a classification that is finer than the binary one between primary and derivative terms. If there are three related terms T_1, T_2 and T_3 such that the following three conditions are fulfilled: (1) T_1 is a primary term, (2), T_2 is a term derived from T_1, (3) T_3 is a term derived from T_2, then the derivation order between T_1 and T_2, as well as T_2 and T_3, can be described as one, since no derivative terms exist between T_1 and T_2 (or T_2 and T_3). The derivation order between T_1 and T_3 can then be described as two as there is one term (T_2) separating T_1 from T_3. The idea can be expanded to include higher orders as well.

Chemical terminology readily lends itself to classification using conceptual derivation[24]. If the term *molecule* is taken as a starting point (a primary term), then the terms *molecular compound* and *chemical bond* can be described as its first-order derivative terms. If the terms *bond order*, *bond polarity* and *covalent bond* are added to the picture, these can be described as being derived from *chemical bond*, thus constituting second-order derivative terms. A simple graph illustrates this well.

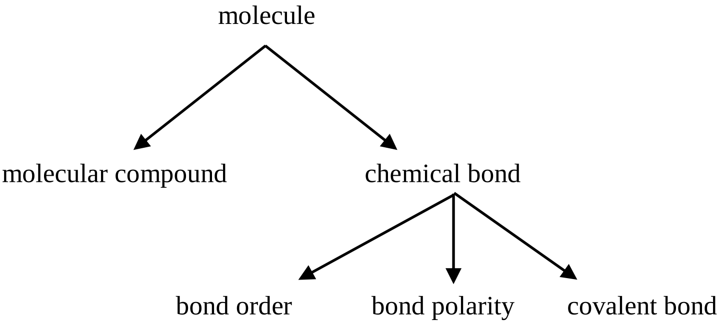

Fig. 5. A partial network for the term *molecule*

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[24] A preliminary investigation of how this could be done can be found in Michta (2009).

This classification of terms can be used to reflect not just the conceptual state of a given discipline but also its development over time. Any change to the terminology of a given discipline can be analysed in terms of new concepts that are created. For well-established disciplines, it can be expected that more changes to the terminology will occur within second-order derivative terms (or derivative terms of higher orders) than first-order derivative terms, as the latter are more firmly anchored in the terminology of the discipline. The formation of a second-order derivative term within a well-established discipline is also more likely to occur than the emergence of a first-order derivative term since there exist more possible combinations through which second-order terms can be formed. In terms of relative importance, a new first-order derivative term is likely to have far-reaching consequences for the whole terminological system since it may directly or indirectly (i.e. together with other first-order derivative terms) lead to the formation of new second-order derivative terms. By contrast, the formation of a new second-order derivative term has a lower potential to bring about a major shift in an established system of terms. Key terms enjoy a special position in the terminology of a given discipline. As has been stated previously, they govern other terms. Accordingly, when a new key term is formed or when an already existing key term is dismissed as being no longer useful, the implications for the whole terminological lexicon can be far-reaching. The classification of terms discussed here lends itself as a tool for synchronic and diachronic studies into terminology and can be used to augment other approaches (see Strehlow 1993: 129–131).

Another aspect of basing a classification of terms on conceptual derivation is concerned with knowledge of terminology. One might expect for a pair of terms, one of which is a primary term and the other is its derivative term, that knowing the derivative term should also imply knowing its primary term[25]. Referring to an earlier example, a person who knows the term *metre* can be expected to also know the term *length*. In a similar vein, if a person understands the terms *reactant* and *molecule*, they should also understand their primary terms, i.e. *chemical reaction* and *atom*, respectively. Further examples abound. Such assumptions can be proven wrong in individual cases, however. One may know a derivative term (e.g. *reactant*) and yet not know the precise meaning of the primary term (e.g. *chemical reaction*). It seems, however, far less likely that

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[25] Similar considerations have also been made by A. Wierzbicka (1996: 10), albeit her focus is on general vocabulary rather than terminology.

a person who understands a derivative term, will not understand its primary term at all. In fact, in that case doubts can be raised as to whether the derivative term is fully understood in the first place. Despite these reservations it seems reasonably justified that generally knowledge of derivative terms presupposes knowledge of their primary terms.

It can be argued that classifying terms on the basis of conceptual derivation also has significant implications for learning terminology and teaching it. While acknowledging that teaching and learning are complex processes and numerous factors play a role in determining the order in which individual units are taught/learnt, conceptual derivation may be leveraged as a guiding criterion in the teaching and learning process. Since primary terms constitute the conceptual basis for the whole system, they typically need to be learned first. Only after these are familiar should the learner proceed to first-order derivative terms and subsequently to second-order derivative terms and derivative terms of higher orders. A critical factor in determining the order in which it seems beneficial to learn/teach terms is whether the terms presupposed by a given term have already been taught/learnt. As regards key terms, their knowledge is of little avail if the user is not conversant with the terms that they govern. It may therefore be beneficial to teach/learn them together with the terms that they order or after such terms have been taught/learnt. Apart from informing the order in which terms are taught/learnt, conceptual derivation may also become a factor in establishing which terms to include in the terminological minimum of a field (see Łukasik 2018). The need for frequency lists still remains (for chemistry see Valipouri and Nassaji 2013) in this context, but if trusted blindly these can be misused, especially if no qualitative criteria are employed for term selection purposes.

Bearing the above considerations in mind, a systematic dictionary, which uses conceptual derivation in arranging the entries, can be a valuable tool for teaching and learning as it reveals conceptual relations between terms. By indicating the interdependencies between terms, it fulfils one of the criteria for the ideal terminological dictionary, as described by W. Zmarzer (1991: 124). One of the most salient features of such a dictionary is the fact that it is an attempt to represent selected aspects of specialised knowledge by identifying the place within the conceptual network of a given discipline where a term can be found and by presenting it explicitly. In other words, it is an attempt to furnish the user with a conceptual map that reflects the state of a discipline at a given point in time. Hence systematic dictionaries seem to be well suited to the needs of the teaching/learning process.

2.5. The main assumptions for the model

As stated in the Introduction, the main objective of the book consists in developing a model of an English-Polish dictionary of chemical terminology and illustrating it with a sample of such a dictionary. Drawing on the preceding sections, the remaining part of this chapter looks at the main assumptions for the model and discusses how these can be implemented.

2.5.1. Aims of the dictionary and its target group

Before addressing the question of the structure of the proposed dictionary of chemical terminology, one has to ask a question that seems most important when compiling a dictionary, namely the question relating to the target group. In turn, this question is closely related to that of the aims of the dictionary. The answers to these questions considerably affect the finished work.

Broadly speaking, the dictionary is intended for all those who have an interest in English and Polish chemical terminology and would like to expand their knowledge in that respect. Thus the target group may be described as including students of chemistry, chemists, translators of chemical or scientific texts, chemistry enthusiasts and others who want to learn more about English and Polish chemical terminology. More specifically, the dictionary may be especially useful for native Polish users who are beginners when it comes to English terminology and would like to study it or revise it in a systematic manner. Although the dictionary is aimed at users with a low level of competence in chemistry, a few rudimentary terms may already be known to the user. As regards the expected language competence of the intended readership, the dictionary assumes at least an upper-intermediate command of English, as otherwise English language definitions may not be understood correctly.

The main aim of the dictionary is to assist its users in learning English (and Polish) chemical terminology and in developing an understanding of how individual terms are interrelated. Two aspects have been merged into this broad aim. First, the dictionary is intended to help its users to understand the meanings of individual terms. Since the dictionary is geared predominantly towards beginners with respect to chemical terminology, such information seems essential. Another reason for explaining the meanings of individual terms is the fact that this very information provides the foundation for establishing the relationships between individual terms. Second, while the focus is on English terminology, Polish translations are provided for every term defined in the dictionary. In this way, the user may learn or revise Polish equivalents for English terms. Since in the case of chemical terminology, full equivalence between terms in English and in Polish is commonplace, which is partly due to standardisation, learning Polish terminology boils down to learning a linguistic form, which in many cases bears close resemblance to the English one. In sum, the dictionary is intended to help its users expand their subject-field knowledge of chemistry as well as improve their familiarity with Polish equivalents of English terms.

2.5.2. Macrostructure of the dictionary

The choice of a systematic dictionary determines to a considerable extent the macrostructure of a dictionary, i.e. the arrangement of entries within a dictionary (Burkhanov 2010: 146–147), inasmuch as the macrostructure needs to reveal semantic relations in this case. However, the actual macrostructure of such a dictionary may vary from dictionary to dictionary as numerous possible arrangements exist that take into account semantic relations between the entries. Unlike alphabetical macrostructures which dominate the dictionary market and enjoy a privileged status due to their familiarity, macrostructures that reveal semantic relations are in the minority and may seem somewhat impenetrable to the user. It is also considerably easier for lexicographers to rely on the alphabet as an ordering principle, not least because the comparatively few problems attendant on arranging the wordlist according to the alphabet are described in detail in literature. By opting for a semantic macrostructure, however, the lexicographer is faced with the task of developing an exact policy with regard to entry arrangement. In the case of a systematic dictionary of chemical terminology, it seems both reasonable and beneficial to present chemical terminology in modules. For any field whose terminology is so rich and diverse as that of chemistry this solution is nothing short of vital, if the dictionary is to include more than a small number of entries while still remaining user-friendly. Additionally, the modular approach to the presentation of terminology in the proposed dictionary finds further support in the claim that terminology itself can be thought of as consisting of modules (Lukszyn and Zmarzer 2001: 130–131).

The question arises of how to divide the terminology of chemistry into modules, so that the needs of the user can be best served. The division of chemistry into subdisciplines presented in Section 1.4 seems to provide a tentative answer to this question. If, however, no further subdivisions were made, the number of terms in the resulting modules would differ greatly from module to module. In order to prevent this and also to ensure that the user is not overwhelmed with too great a number of terms in an individual module, developing a more fine-grained distinction is recommended. By adding modules devoted to specific aspects of general chemistry and subdividing physical chemistry one can propose the following modules given in alphabetical order: atom, chemical kinetics, chemical reaction, chemical thermodynamics, compound, electrochemistry, inorganic chemistry, nuclear chemistry, organic chemistry, solution.

If modules are ordered alphabetically, this furnishes no information on the relations between them. Therefore an ordering of modules based on their interdependencies seems superior. An example of such an ordering is: atom, compound, chemical reaction, solution, chemical kinetics, chemical thermodynamics, electrochemistry, nuclear chemistry, inorganic chemistry, organic chemistry. It is of course possible to order the modules differently. One might argue that inorganic chemistry and organic chemistry should be featured earlier in the list. However, the proposed order of modules closely corresponds to the order followed by several chemical textbooks (see for instance Timberlake 1996, Bielański 1998, Sienko and Plane 2002, Brown et al.: 2012), which is why it is adopted as the basis for the dictionary in Chapter 3. The modules that appear to the right of a given module usually require at least a passing knowledge of the previous module or modules. For instance, module 3 (chemical reaction) builds on module 2 (compound) as well as module 1 atom). By ordering individual modules in this way, thematic progression can be achieved, which may be considered an asset as the dictionary guides the user through the process of selecting which module to focus on.

In addition to ordering modules on the basis of their interdependencies, the terms in each module have also been arranged in this way. With respect to the specific ordering policy, it seems advantageous to base it on the distinction between primary terms, first-order derivative terms, second-order derivative terms and key terms and place each of these classes in precisely that order as it corresponds to how individual terms can be derived from one another (key terms may be seen as an exception here). The classification used does not go beyond second-order derivative terms. These could be included if the dictionary were to cover more terms but, in the sample expanding the classification, it proved unnecessary. By distinguishing between all those classes of terms in an explicit manner, each module will provide clear suggestions as to which terms are semantically more complex than others and offer guidelines as to which the user may want to study first. An earlier study of chemical terminology (Michta 2015) found that even for a small number of terms, there are borderline cases which could be classified as belonging to two modules or more. The problem is clearly compounded if a larger set of terms is analysed, e.g. in the dictionary sample. When considering such cases, priority should be given to user needs. Having decided on the division of chemical terminology into modules and using a classification of terms based on conceptual derivation, the only issue that remains with respect to arranging the entries concerns the order of terms within each class. Here it seems that the alphabetical arrangement of terms is justified.

In order to give the user an overview of the terms included in a given module, each module will start with a graphic representation of its contents as exemplified below.

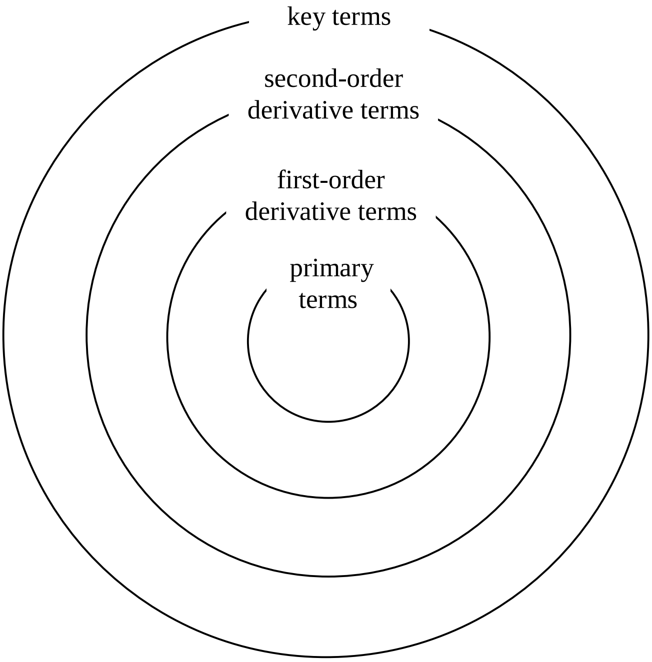


Fig. 6. A terminological atom

This schematic, reminiscent of representations of an atom, may be called a terminological atom. Located in its centre are primary terms that correspond to an atomic nucleus. Further removed from the centre are first-order and second-order derivative terms, which occupy two shells in the atom. As with a chemical atom and it shells, their distance from the nucleus suggests that first-order derivative terms are affected by the primary terms to the greatest extent, while the effect of the centre on second-order derivative terms is lesser. Key terms, which occupy the outermost shell of the atom, mark the outer limit of the terminological atom. Apart from providing an overview of the structure of a module, this schematic has the added advantage of having a mnemonic function.

2.5.3. Microstructure of the dictionary

The microstructure of a dictionary is the arrangement of lexicographic information within dictionary entries (Burkhanov 2010: 155). A detailed list of the types of information that may be appear in a specialised dictionary is provided by W. Zmarzer (2004: 66). Which of these information types are actually chosen for inclusion hinges on the aims of a dictionary. For the purposes of the practical part of the dictionary, the following types of information have been selected for every English term: English synonyms (if applicable), Polish equivalent, synonyms for the Polish term, irregular plural form of the English term (if applicable), symbol, definition, references to related terms.

Synonyms for English terms are worth including in the dictionary as long as they are sufficiently common and refer to the exact same concept. While the existence of synonymy in terminology has sometimes been frowned upon in terminological circles (see Temmerman 2000: 10), it has persisted in spite of opposition to it. A number of synonyms were identified while compiling the dictionary sample included in Chapter 3 (e.g. *atomic number* and *proton number*). Their inclusion helps the user discover alternative ways of expressing the same concept. Besides, if the dictionary limited itself only to entry terms (e.g. *atomic number*), the user would not be able to locate the entry for a term whose synonym they are looking up.

Polish equivalents are necessary if the dictionary is to become a bilingual dictionary. One of their functions is to enable the user to translate a given term into Polish and to expand their knowledge of Polish terminology. The explanatory function of target-language equivalents that is typical of general-language dictionaries (Zgusta 1971: 320) may, however, be lost. Unless the user is already familiar with the meaning of the term, its Polish equivalent does not serve to explain it. Since, as a result of strict definitions and standardisation, full equivalence is to be expected between an English term and its Polish equivalent in the dictionary, no additional information on the meaning of the Polish term is needed. Additionally, the Polish term can also be a starting point if the user does not know the English term that they would like to look up.

As symbols are not uncommon in chemistry and are frequently used to replace terms, they should also be mentioned in an entry. In common with synonyms, they can also be used in place of a term, but may be preferred in certain contexts to synonyms due to pragmatic factors, e.g. in equations. In the dictionary sample, symbols, if any, precede the respective definitions.

Irregular plural forms of English terms are the only type of information included in the dictionary that may be deemed grammatical. While the dictionary itself does not aspire to be an active dictionary (Hartmann and James 1998: 3), by providing information on irregular forms it may help the user with an aspect of the terms that they may struggle with. It may also prove indispensable for identifying the correct entry if the user uses the plural form as a starting point for look-up.

A crucial role in the dictionary is played by definitions. Therefore, care needs to be taken in selecting them. This relates both to the type of definition as well as their harmonisation. As regards the former, there exists a number of different definition types (see Sager 1990: 42–44, Arntz, Picht, and Mayer 2004: 60–66, Lukszyn and Zmarzer 2006: 135). One of these is the definition by intension (intensional definition), which can be defined in the following manner (Felber 1984: 160–161):

> A definition by intension consists of a specification of the characteristics of the concept to be defined, i.e. the description of the intension of the concept. For this purpose first the nearest genus that has either been defined already or can be expected to be generally known […] is found. The genus is restricted to the correct extension by its linking to characteristics, which differentiate the concept to be defined from other concepts of the same level of abstraction.

This type of definition merits attention as it may be deemed optimal for the purposes of the present study (Temmerman 2000: 9, Lukszyn and Zmarzer 2006: 161–163). Its main advantage lies in the fact that it explicitly indicates the generic term as well as the characteristics of a given term, thus indicating the relationships between the defined term and other terms. As long as it is possible, intensional definitions are provided in the dictionary sample.

It is also important to remember that in both a general dictionary and a specialised dictionary not only the type of definitions but also their wording requires forethought. Any specialised dictionary should strive for user-friendliness without unnecessarily compromising its accuracy. An important aspect of user-friendliness in a learner's dictionary is tailoring the language of the definitions to the expected levels of language and subject-field competence of the intended readership. Additionally, the compiler of a dictionary needs to strive to achieve harmonisation of definitions so that all definitions constitute a coherent text that facilitates the use of the dictionary in question. To this end, a uniform system of linguistic formulae and a restricted set of criteria that may be invoked in definitions need to be developed and followed (Kielar 2001: 143). This condition, if fulfilled, creates a sense of familiarity in the user. The practical part of the book attempts to implement this principle.

An important feature of the dictionary sample presented in Chapter 3 is the use of examples which appear when explaining meanings. These are introduced by means of the phrase *for example*. In order to achieve greater harmonisation, examples cited within a module are related to one another. For instance, the entry for *nuclear number*, a first-order derivative term, uses the example of carbon-12, and the entry for *mass number*, a second-order derivative term, refers to the same example. By contrasting similar terms in this way, the dictionary assists the user in understanding the definitions.

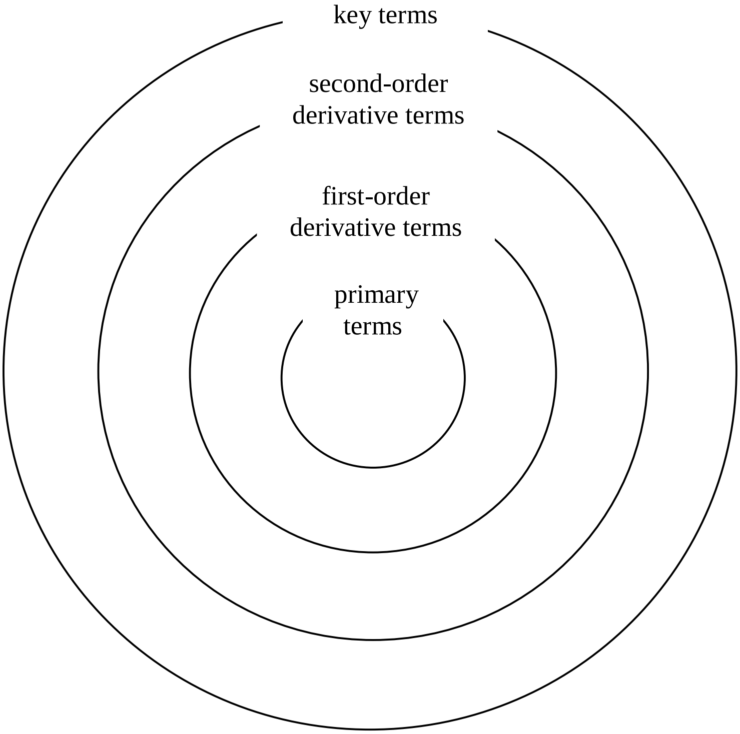
Cross-references to other terms are an essential feature of specialised dictionaries (Waszczuk 2004: 141). Relationships that are often used in terminology include: generic relationships, partitive relationships, and contradictive relationships. The full list includes many more elements (see Lukszyn and Zmarzer 2006: 152). A systematic dictionary could in principle also include such relationships. However, since its structure is strongly influenced by conceptual factors, it seems that certain relationships are more relevant and should be given priority. For any term within a module, the issue of whether it is closely related to other terms that can be found in the same class may be important to the user. *Ionic bond* and *covalent bond* are a good case in point as they are related through co-hyponymy (Lyons 1977: 291). For primary terms and first-order derivative terms, it is important to indicate which terms can be conceptually derived from them. For first-order derivative terms and second-order derivative terms, information on which terms they derive from is worth including. Finally, for key terms an indication of which exact terms they govern will provide useful information to the user. Chemical terms may enter into relationships with terms from the same module but also from other modules. In the dictionary sample only in the former case were such relationships indicated lest the user be overwhelmed with an excessive number of cross-references.

Chapter 3

An English-Polish Systematic Dictionary of Chemical Terminology

User's guide

- The dictionary's main aim is to provide help with learning English (and Polish) chemical terminology and develop an understanding of how individual terms are interrelated
- The dictionary is intended for all those who have an interest in English and Polish chemical terminology and would like to expand their knowledge in that respect. It may be especially useful for native Polish users who are beginners when it comes to English terminology and would like to learn it from scratch or revise it in a systematic manner.
- The dictionary includes 210 entries devoted to fundamental chemical terms that have been grouped into ten modules: atom, compound, chemical reaction, solution, chemical kinetics, chemical thermodynamics, electrochemistry, nuclear chemistry, inorganic chemistry, and organic chemistry. The division into modules makes it possible to study terms from a specific field only. It is advisable to start with the first module and then proceed to the next ones following the suggested order since modules that appear later in the dictionary build upon knowledge gleaned in the previous ones. However, the user may decide to change the order in which they consult individual modules.
- Each module begins with a short description of its scope, followed by a terminological atom, i.e. a graphic representation of all the terms which are included in the module. The structure of terminological atoms is as follows (see overleaf):



- Within each module, terms have been divided into four groups, expressing their interdependence. Primary terms appear first and they constitute the basis for each module. Next are first-order derivative terms, i.e. those that can be directly derived from primary terms. First-order derivative terms are followed by second-order derivative terms, i.e. those that can be derived from first-order derivative terms. Key terms as understood in this dictionary refer to various chemical principles and laws, and as such they express relationships between terms or describe the relationships between the objects that terms refer to.
- The arrangement of terms is shown by means of a terminological atom. Primary terms can be found in its centre (i.e. its nucleus). The first shell is occupied by first-order derivative terms and the second by second-order derivative terms. Key terms are placed in the outermost shell. The terms in each shell are ordered alphabetically going clockwise.

- Each entry consists of an English term on the left and its Polish equivalent on the right. If there are synonyms of an English or Polish term, these are also included and preceded by an equals sign. Irregular plural forms are also provided in parentheses and are preceded by the abbreviation *pl.* Definitions of terms are given in English and the majority of them are accompanied by examples, which is intended to help understand them better. The last part of an entry contains information on the relationships of the term with other terms within the module. The following symbols are used:

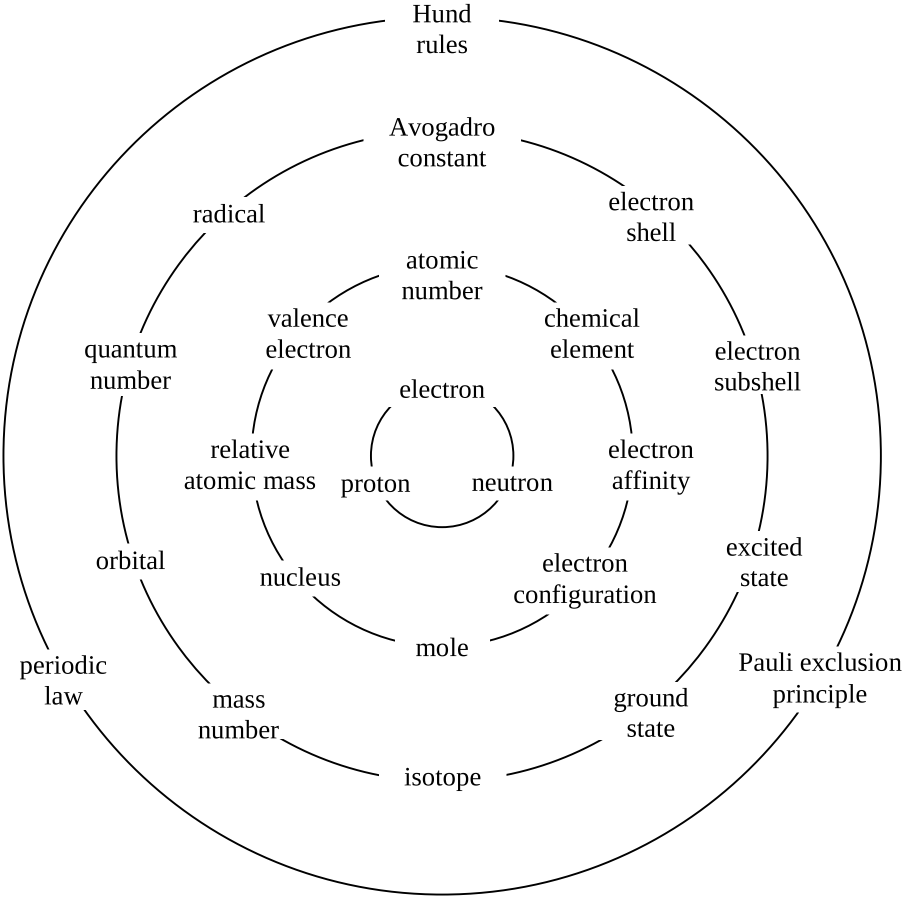
↑	refers to a term from which the given term is derived.
↔	refers to a term which is closely related to a given term and is located in the same shell.
↓	refers to a term which can be derived from a given term.
< >	refers to a term that is governed by a key term.

  By following these symbols, the user can discover the links between different terms and thus gain a better understanding of chemical terminology.
- The dictionary is accompanied by an English-Polish and a Polish-English index of terms, both of which are arranged alphabetically. Their aim is to direct the user to find the appropriate entry in the main part of the dictionary. An English-Polish list of chemical elements has also been added to complement the main body of the dictionary.

Module 1

Atom – atom

The smallest particle still characterizing a chemical element. Atoms consist of a small nucleus of protons and neutrons surrounded by electrons. The number of electrons equals the number of protons so the overall charge is zero.



Primary terms

electron	**elektron**
def.	Symbol (e^-). An elementary particle with a mass of 9.109 x 10^{-31} kg and a negative charge of 1.602 x 10^{-9} C. In atoms, electrons occupy electron shells. The interaction of electrons with adjacent nuclei is the main cause of chemical bonding.
↔	neutron, proton
↓	electron affinity, electronic configuration, mole, valence electron

neutron	**neutron**
def.	Symbol (n). A neutral elementary particle that is stable in the atomic nucleus. Its rest mass is 1.674 x 10^{-27} kg. Neutrons occur in all nuclei except normal hydrogen.
↔	electron, proton
↓	mole, nucleus, relative atomic mass

proton	**proton**
def.	Symbol (p^+). An elementary particle that is stable with a mass of 1.672 x 10^{-27} kg and a positive charge of 1.602 x 10^{-9} C. Protons occur in all atomic nuclei.
↔	electron, proton
↓	atomic number, chemical element, mole, nucleus, relative atomic mass

First-order derivative terms

atomic number **= proton number**	**liczba atomowa** **= liczba protonów**
def.	Symbol (Z). The number of protons in the nucleus of an atom. The atomic number is equal to the number electrons orbiting the nucleus in a neutral atom and is unique for each element. It is usually written as a subscript to the left of the element symbol directly below the mass number. For example, carbon-12 ($^{12}_{6}C$) has an atomic number of 6.
↑	proton
↔	chemical element, nucleus, relative atomic mass
↓	isotope, mass number

chemical element	**pierwiastek chemiczny**
def.	A species of atoms; all atoms with the same number of protons in the atomic nucleus. The term is also used to refer to a pure chemical substance composed of atoms with the same number of protons. There are 92 naturally occurring elements.
↑	proton
↔	atomic number, mole
↓	isotope, mass number

electron affinity	**powinowactwo elektronowe**
def.	Symbol (E_{ea}). The energy released when a neutral atom or molecule gains an electron to form a negative ion. For an atom or molecule X, it is the energy released in the process: $X + e^- \rightarrow X^-$
↑	electron
↔	electronic configuration, valence electron

electronic configuration	**konfiguracja elektronowa**
def.	The spatial arrangement of electrons around the nucleus of an atom. The most stable electronic configuration is that in which the electrons are in the lowest possible energy states. The state of an electron in an atom is given by quantum numbers.
↑	electron
↔	electron affinity, valence electron
↓	excited state, ground state, orbital, radical, quantum number, shell, subshell

mole	**mol**
def.	Symbol (mol). The SI base unit for amount of substance. It is equal to the amount of substance that contains as many elementary units as there are atoms in 0.012 kilogram of carbon-12. When the mole is used, the elementary units must be specified and may be atoms, molecules, ions, electrons, or other particles.
↑	electron, neutron, proton
↔	chemical element
↓	Avogadro constant

nucleus **(pl. nuclei, nucleuses)**	**jądro**
def.	The positively charged central core of an atom. It contains most of its mass and consists of protons and in most cases also neutrons. The simplest nucleus is the hydrogen nucleus, which consists of one proton only. All other nuclei contain at least one neutron.
↑	neutron, proton
↔	atomic number, relative atomic mass
↓	isotope, mass number

relative atomic mass **=atomic weight**	**względna masa atomowa** **= ciężar atomowy**
def.	Symbol (Ar). The ratio of the average mass of the atom to 1/12 of the mass of a carbon-12 atom. For example carbon, C, has a relative atomic mass of 12.
↑	neutron, proton
↔	atomic number, nucleus

valence electron	**elektron walencyjny**
def.	An electron that is situated furthest from the nucleus. Valence electrons are involved in chemical bonding. The number of valence electron affects the stability of the atom. Atoms with few valence electrons tend to be more stable than atoms with many valence electrons.
↑	electron
↔	electron affinity, electronic configuration, nucleus
↓	radical

Second-order derivative terms

Avogadro constant	**stała Avogadro**
def.	Symbol (L) or (N_A). The number of atoms or molecules in one mole of substance. It is equal to 6.022 x 10^{23}.
↑	mole

electron shell	**powłoka elektronowa**
def.	An energy level containing electrons of similar energies. The electron shells are labelled K, L, M, N, O, P, and Q; or 1, 2, 3, 4, 5, 6, and 7. The number of electrons that can exist in a shell is equal to $2n^2$, where n is the shell number.
↑	electronic configuration
↔	electron subshell, orbital, quantum number

electron subshell	**podpowłoka elektronowa**
def.	A group of energies having identical energies. The different types of subshells are identified by the letters s, p, d, and f. The s subshell is lowest in energy, followed by the p subshell, then the d subshell, and finally the highest energy subshell, the f subshell.
↑	electronic configuration
↔	electron shell, orbital, quantum number

excited state	**stan wzbudzony**
def.	A state of an atom, molecule, etc. when the species has absorbed energy and become excited to a higher energy state as compared with the ground state.
↑	electronic configuration
↔	ground state, quantum number

ground state	**stan podstawowy**
def.	The lowest energy state of an atom, molecule, etc. The ground state of the hydrogen atom corresponds to having the atom's single electron in the lowest possible orbit.
↑	electronic configuration
↔	excited state, quantum number

isotope	**izotop**
def.	One of two or more atoms of the same element that have the same number of protons in their nucleus but different numbers of neutrons. Protium (1 proton, no neutrons), deuterium (1 proton, 1 neutron), tritium (1 proton, 2 neutrons) are all isotopes of hydrogen. Most elements in nature consist of a mixture of isotopes.
↑	electronic configuration
↔	mass number

mass number **= nucleon number**	**liczba masowa** **= liczba nukleonów**
def.	Symbol (A). The number of protons and neutrons in the atomic nucleus. The mass number is unique for each isotope of an element and is written either after the element name or as a superscript to the left of an element's symbol. For example, carbon-12 ($^{12}_{6}\mathrm{C}$) has 6 protons and 6 neutrons.
↑	atomic number, chemical element, nucleus
↔	isotope

orbital	**orbital**
def.	A region in space when an electron is most likely to be found. An orbital can hold only one or two electrons. There is a special shape of orbitals in each type of shell.
↑	electronic configuration
↔	electron shell, electron subshell, quantum number

quantum number	**liczba kwantowa**
def.	Any of a class of numbers that are used to describe the state of a quantum system. They often describe the energies of electrons in atms, but may also describe angular momentum, spin, etc.
↑	electronic configuration
↔	electron shell, electron subshell, excited state, ground state, quantum number, radical

radical	**rodnik**
def.	An atom or group of atoms possessing an unpaired valence electron. Because of their unpaired valence electron, most free radicals are extremely reactive.
↑	valence electron, electronic configuration
↔	quantum number

Key terms

Hund rules	**reguły Hunda**
def.	Empirical rules used to determine the lowest energy level for a configuration of two equivalent electrons in a many-electron atom. According to these rules, each orbital has one electron placed in it before pairing of electrons in orbitals occurs. The rules were put forward by Friedrich Hund in 1925.
↔	Pauli exclusion principle
< >	electronic configuration, orbital, quantum number

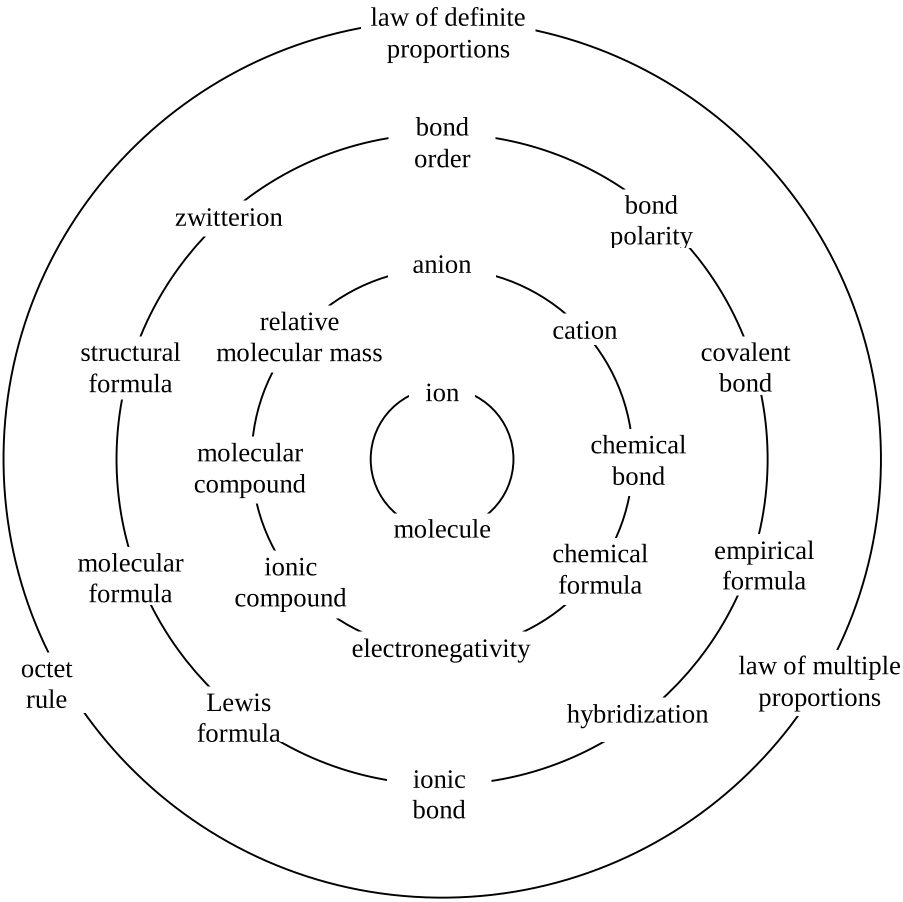
Pauli exclusion principle	**zakaz Pauliego**
def.	The principle stating that no two electrons in an atom can have all four quantum numbers the same. It was first formulated in 1925 by Wolfgang Pauli.
↔	Hund rules
< >	electronic configuration, orbital, quantum number, electron shell, electron subshell

periodic law	**prawo okresowości**
def.	The principle stating that the physical and chemical properties of elements vary periodically with their proton number. The concept was first proposed in 1869 by Dimitri Mendeleev. The law can be used to predict chemical and physical properties of undiscovered elements and compounds.
< >	atomic number, chemical element, electronic configuration, electron affinity

Module 2

Compound – związek chemiczny

A substance consisting of elements chemically combined in fixed proportions.
The formation of a compound involves a chemical reaction.
Compounds cannot be separated by physical means.



Primary terms

ion	**jon**
def.	An atom or group of atoms that has either lost one or more electrons, making it positively charged (a cation), or gained one or more electron, making it negatively charged (an anion). The net charge on an ion is shown as a superscript. For example: Na^+ and Cl^-.
↔	molecule
↓	anion, cation, chemical bond, chemical formula, electronegativity, ionic compound

molecule	**cząsteczka**
def.	A group of a least two atoms which represents a chemical substance and retains its properties. A molecule has a neutral net charge. In most covalent compounds, molecules consist of groups of atoms held together by bonds. Ionic compounds do not have single molecules, as they are collections of oppositely charged ions.
↔	ion
↓	chemical bond, chemical formula, electronegativity, molecular compound, relative molecular mass

First-order derivative terms

anion	**anion**
def.	A negatively charged ion, formed when an atom gains electrons in a reaction. Anions are negatively charged because they have more electrons than there are protons in their nuclei. The net charge on an anion is represented by a superscipt; $^-$, $^{2-}$, and $^{3-}$ represent net charges resulting from the gain of one, two, or three electrons, respectively. An example is chloride anion, Cl^-.
↑	ion
↔	ionic compound, cation
↓	zwitterion

cation	**kation**
def.	A positively charged ion, formed when an atom loses electrons in a reaction. Cations are the opposite of anions, since cations have fewer electrons than protons. The net charge on an cation is represented by a superscript; $^{+}$, $^{2+}$, and $^{3+}$ mean a net charge resulting from the loss of one, two, or three electrons respectively. An example is the sodium ion, Na^+.
↑	ion
↔	anion, ionic compound
↓	zwitterion

chemical bond	**wiązanie chemiczne**
def.	A strong force of attraction holding atoms together in a molecule or crystal. The formation of bonds involves interactions of the outermost electrons of atoms.
↑	ion, molecule
↔	electronegativity, ionic compound, molecular compound
↓	bond order, bond polarity, covalent bond, hybrydization, ionic bond, Lewis formula

chemical formula (pl. formulas or formulae)	**wzór chemiczny**
def.	A notation that uses atomic symbols with numerical subscripts to convey the relative proportions of atoms of the different elements in a substance. Examples of chemical formulae include CH_2O and $C_2H_4O_2$.
↑	ion, molecule
↔	ionic compound, molecular compound
↓	empirical formula, molecular formula, structural formula

electronegativity	**elektroujemność**
def.	Symbol (χ). A numerical measure of the ability of an atom to compete with other atoms for the electrons between them. Fluorine is the most electronegative element, meaning that it has the strongest ability to attract electrons from other atoms. Electronegativity generally increases from left to right in a row of the periodic table, and decreases going down the column.
↑	ion, molecule
↔	chemical bond
↓	bond polarity, covalent bond, ionic bond

ionic compound	**związek jonowy**
def.	A compound composed of anions and cations. Because ionic compound are electrically neutral, they usually contain both metallic and nonmetallic elements. The chemical formulae used to represent ionic compounds are empirical formulae. An example is sodium chloride, NaCl.
↑	ion
↔	anion, cation, chemical bond, chemical formula, molecular compound
↓	empirical formula, ionic bond

molecular compound	**związek cząsteczkowy**
def.	A compound that consists of molecules that are hold together by sharing electrons. Molecular compounds usually contains only nonmetallic elements. They are usually represented by molecular formulae. An example is carbon dioxide, CO_2.
↑	molecule
↔	chemical bond, chemical formula, ionic compound, relative molecular mass
↓	covalent bond, empirical formula, Lewis formula, molecular formula, structural formula

relative molecular mass **= relative molar mass,** **molecular weight**	**masa cząsteczkowa względna** **= masa molowa względna,** **ciężar cząsteczkowy**
def.	Symbol (M_r). The ratio of the average mass per molecule of the naturally occurring form of an element or compound to 1/12 of the mass of carbon-12 atom. It is equal to the relative atomic masses of all atoms that comprise a molecule. For example carbon dioxide, CO_2, has a relative atomic mass of 44.
↑	molecule
↔	molecular compound

Second-order derivative terms

bond order	**rząd wiązania**
def.	A value indicating the degree of bonding between two atoms in a molecule relative to a single bond. Bond orders are theoretical values depending on the way the calculation is done. For example, in ethane, C_2H_6, the bond order of the C—C bond is 1. In ethene, C_2H_4, the bond order is 2.
↑	chemical bond

bond polarity	**polarność wiązania**
def.	A numerical measure of how equally the electrons are shared between the two atoms in a chemical bond. If the electrons are shared equally between the two atoms, the bond is nonpolar. If one of the atoms exerts a greater attraction for the bonding electrons than the other, the bond is polar.
↑	chemical bond, electronegativity
↔	covalent bond, Lewis structure

covalent bond	**wiązanie kowalencyjne**
def.	A chemical bond formed between two or more atoms by a sharing of electrons. For example, a covalent bond exists in the hydrogen molecule (H_2).
↑	chemical bond, electronegativity, molecular compound
↔	bond polarity, hybridization

empirical formula (pl. formulas or formulae)	**wzór cząsteczkowy**
def.	A chemical formula that indicates the simplest ratio of elements in a compound. For example, the empirical formula of the ethanoic acid is CH_2O.
↑	chemical formula, ionic compound, molecular compound
↔	molecular formula, structural formula

hybridization	**hybrydyzacja**
def.	The process whereby atomic orbitals of different type but similar energies are combined to produce a set of equivalent hybrid orbitals. For example, in methane, CH_4, which contains four equivalent C—H bonds, it may be considered that the C-atom 2s and 2p orbitals are hybridized to give four equivalent sp^3 orbitals which are then each combined with an H-atom 1s orbital.
↑	chemical bond
↔	covalent bond

ionic bond	**wiązanie jonowe**
def.	A bond formed on the basis of the electrostatic forces that exist between oppositely charged ions. The ions are formed by transfer of one or more electrons. For example, an ionic bond exists in sodium chloride (NaCl).
↑	chemical bond, electronegativity, ionic compound

Lewis formula **(pl. formulae or formulas)** **= Lewis structure,** **electron dot structure**	**wzór Lewisa** **= struktura Lewisa,** **wzór kropkowy**
def.	A chemical formula used to represent covalent bonding in a molecule. Shared electron pairs are shown as lines, and unshared electron pairs are shown as pairs of dots. Only outermost electrons of atoms are shown. For example, the Lewis structure for the hydrogen molecule, H_2 is H–H.
↑	chemical bond, molecular compound
↔	covalent bond

molecular formula **(pl. formulas or formulae)**	**wzór cząsteczkowy**
def.	A chemical formula that shows the actual numbers and kinds of atoms in a molecule. For example, the molecular formula of the ethanoic acid is $C_2H_4O_2$.
↑	chemical formula, molecular compound
↔	empirical formula, structural formula

structural formula **(pl. formulas or formulae)**	**wzór strukturalny**
def.	A chemical formula that indicates the way the atoms are arranged. Commonly, this is done by dividing the formula into groups. For example, the ethanoic acid can be written $CH_3.CO.OH$ (or more usually simply CH_3COOH). Structural formulae can also show the arrangement of atoms or groups in space.
↑	chemical formula, molecular compound
↔	empirical formula, molecular formula

zwitterion **= ampholyte ion**	**jon obojnaczy**
def.	An ion that carries both a positive and negative charge. Zwitterions can be formed from compounds that contain both acid and basic groups in their molecules. For example, aminoethanoic acid has the formula $H_2N.CH_2.COOH$. However, under neutral conditions, it exists in the different form of the zwitterion $^+H_3N.CH_2.COO^-$.
↑	anion, cation

Key terms

law of constant composition **= law of constant proportions,** **law of definite proportions**	**prawo stałości składu** **= prawo stosunków stałych**
def.	A chemical law stating that the proportions of the elements in a compound are always the same, no matter how the compound is made. Therefore compounds prepared in the laboratory have the same properties as the corresponding compounds found in nature. The law was stated in about 1800 by Joseph Louis Proust.
↔	law of multiple proportions
< >	empirical formula, ionic compound, molecular compound, molecular formula

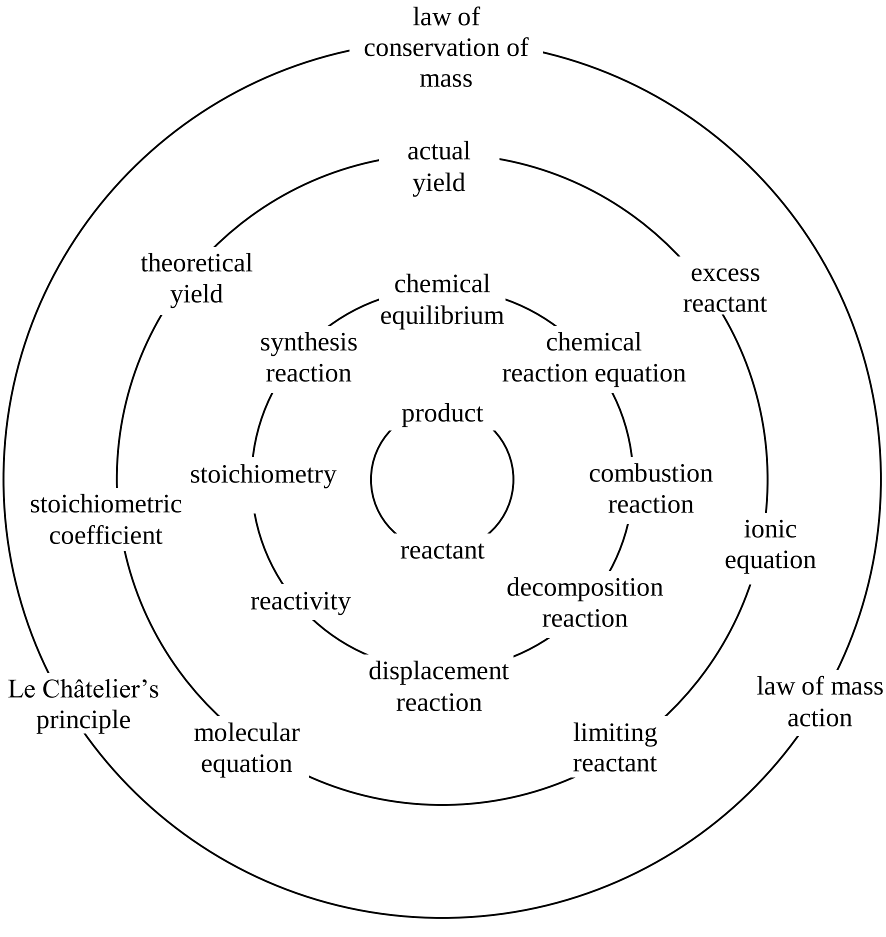
law of multiple proportions	**prawo stosunków wielokrotnych**
def.	A chemical law stating that when two elements A and B combine to form more than one compound, then the masses of B that combine with a fixed mass of A are in simple ratio to one another. For example, in carbon dioxide the oxygen masses combining with a fixed mass of carbon are in the ratio 2:1.
↔	law of constant composition
< >	empirical formula, ionic compound, molecular compound, relative molecular mass

octet rule	**reguła oktetu**
def.	A rule stating that bonded atoms tend to bond in such a way that that each atom has eight valence electronce. This can be viewed as an attempt by atoms to achieve a noble-gas electronic configuration. There are many exceptions to the rule. For example, hydrogen needs only one electron to attain stability. The rule was stated in 1916 by Gilbert Lewis.
< >	ionic compound, Lewis structure, molecular compound

Module 3

Chemical reaction – reakcja chemiczna

A change in which one or more substances (the reactants) form one or more new substances (products). Chemical reactions are different from physical changes, which do not affect the chemical composition of substances.



Primary terms

product	**produkt**
def.	A substance produced in a chemical reaction. It appears to the left of the arrow in a chemical equation. For example, in the reaction $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ the only product is water, H_2O.
↔	reactant
↓	chemical equilibrium, chemical reaction equation, combustion reaction, decomposition reaction, displacement reaction, stoichiometry, synthesis reaction

reactant	**substrat**
def.	A starting substance in a chemical reaction; it appears to the left of the arrow in a chemical equation. For example, in the reaction $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ the reactants are hydrogen, H_2, and oxygen, O_2.
↔	product
↓	chemical equilibrium, chemical reaction equation, combustion reaction, decomposition reaction, displacement reaction, reactivity, stoichiometry, synthesis reaction

First-order derivative terms

chemical equilibrium	**równowaga chemiczna**
def.	The condition in which the concentrations of all reactants and products cease to change with time. Chemical equilibrium occurs when opposing reactions are occuring at equal rates.
↑	product, reactant
↔	reactivity

chemical reaction equation	**równanie reakcji chemicznej**
def.	A way of denoting a chemical reaction using the symbols for the participating particles (atoms, molecules, ions, etc.). When reactions involve different phases, it is usual to put the phase in brackets after the symbol (s = solid, l = liquid, g = gas, aq = aqueous). For example, the synthesis reaction of water can be written as $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
↑	product, reactant
↔	stoichiometry
↓	ionic equation, molecular equation

combustion reaction	**reakcja spalania**
def.	A chemical reaction that proceeds with evolution of heat and usually also a flame. Most combustion involves reaction with oxygen, as in the burning of a match. For example, the combustion of propane, C_3H_8, is described by the following equation: $C_3H_8(g) + O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$
↑	product, reactant
↔	decomposition reaction, displacement reaction, synthesis reaction

decomposition reaction	**reakcja rozkładu** **= reakcja analizy**
def.	A chemical reaction in which a compound breaks down into simpler compounds or into elements. Many compounds undergo decomposition when heated. For example, many metal carbonates decompose to form metal oxides and carbon dioxide when heated: $CaCO_3(s) \rightarrow Ca(s) + CO_2(g)$
↑	product, reactant
↔	combustion reaction, displacement reaction, synthesis reaction

displacement reaction	**reakcja wymiany**
def.	A chemical reaction in which an element or ion moves out of one compound and into another, e.g. $2Na(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2(g)$ or a chemical reaction involving the exchange of bonds between the two reacting chemical species, e.g. $KOH(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(l)$
↑	product, reactant
↔	combustion reaction, decomposition reaction, synthesis reaction

reactivity	**reaktywność**
def.	The relative capacity of an atom, molecule, or radical to combine chemically with another atom, molecule, or radical. Reactivity is a kinetic property.
↑	reactant
↔	chemical equilibrium

stoichiometry	**stechiometria**
def.	The relationships among the quantities of reactants and products involved in chemical reactions. The term is also used for the relative proportions in which elements form compounds.
↑	product, reactant
↔	chemical reaction equation
↓	excess reactant, limiting reactant, stoichiometric coefficient, actual yield, theoretical yield

Second-order derivative terms

actual yield	**wydajność rzeczywista** **= wydajność praktyczna**
def.	The amount of product actually obtained in a reaction. The actual yield is always less than the theoretical yield. Part of the reactants may not react, or they may react in a way different from the desired one.
↑	stoichiometry
↔	theoretical yield

excess reactant	**substrat użyty w nadmiarze**
def.	The reactant present in a quantity that is greater than the stoichiometric quantity. The excess reactant is sometimes left over when the reaction stops.
↑	stoichiometry
↔	limiting reactant

ionic equation	**równanie jonowe**
def.	A chemical equation in which electrolytes are written as dissociated ions. Ionic equations are used for reactions that occur in aqueous solutions. They illustrate what ions and molecules are directly involved in the reaction. For example, $H^+ + Cl^- + Na^+ + OH^- \rightarrow H_2O + Na^+ + Cl^-$ or simply $H^+ + OH^- \rightarrow H_2O$
↑	chemical reaction equation
↔	molecular equation, stoichiometric coefficient

limiting reactant	**substrat użyty w niedomiarze**
def.	The reactant present in the smallest stoichiometric quantity in a mixture of reactants. The amount of product that can form is limited by the complete consumption of the limiting reactant.
↑	stoichiometry
↔	excess reactant

molecular equation	**równanie cząsteczkowe**
def.	A chemical equation in which the formula for each substance is written without regard for whether it is dissolved or not. An example is: $HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$
↑	chemical reaction equation
↔	ionic equation, stoichiometric coefficient

stoichiometric coefficient	**współczynnik stechiometryczny**
def.	The number in front of the formulae in a chemical equation, which show the relative numbers of molecules reacting. For example, in the following reaction: $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ the stoichiometric coefficients are 2, 1, and 2 respectively.
↑	stoichiometry
↔	ionic equation, molecular equation

theoretical yield	**wydajność teoretyczna**
def.	The quantity of product which is calculated to form when all of the limiting reactant reacts. It is usually greater than the actual yield.
↑	stoichiometry
↔	actual yield

Key terms

law of conservation of mass	**prawo zachowania masy**
def.	A chemical law stating that the total mass of the products of a chemical reaction is the same as the total mass of the reactants, so the mass remains constant during the reaction. The law of conservation of mass was first clearly formulated by Antoine-Laurent de Lavoisier in 1789.
↔	law of mass action
< >	chemical reaction equation, combustion reaction, decomposition reaction, displacement reaction, synthesis reaction

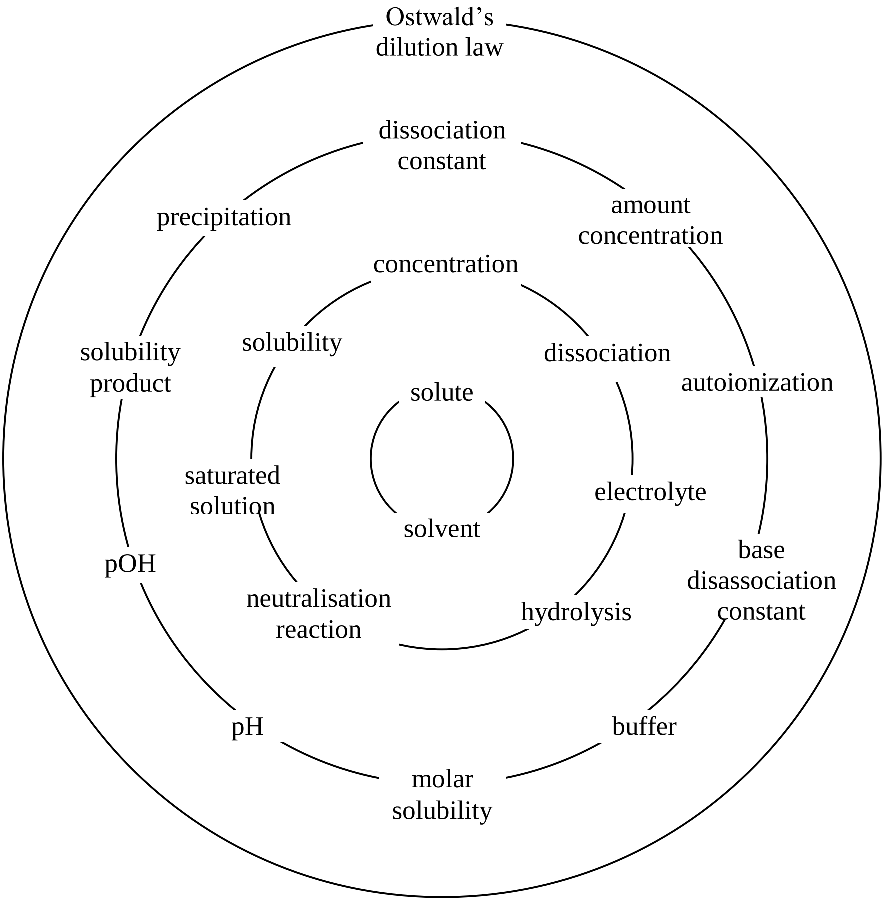
law of mass action	**prawo działania mas**
def.	A chemical law expressing the relationship between the concentration of reactants and products at equilibrium in any reaction. For example, for a reaction: $aA + bB \rightarrow pP + qQ$ the equilibrium condition is expressed by the equation $K_c = [P]^p[Q]^q/[A]^a[B]^b$ The law of mass action was proposed by Cato Guldberg and Peter Waage in 1864.
↔	law of conservation of mass, Le Chatelier's principle
< >	chemical equilibrium, combustion reaction, decomposition reaction, displacement reaction, synthesis reaction

Le Chatelier's principle **= Le Chatelier-Braun principle**	**reguła przekory** **= reguła przekory Le Chateliera-Brauna**
def.	A principle that states that if a system is in equilibrium, any change imposed on the system tends to shift the equilibrium to counteract the effect of the change. The principle was first stated in 1888 by Henri Le Chatelier. For example, in the gas reaction $2SO_2 + O_2 \rightarrow SO_3$ an increase in pressure on the reaction mixture displaces the equilibrium to the right.
↔	law of mass action
< >	chemical equilibrium, combustion reaction, decomposition reaction, displacement reaction, synthesis reaction

Module 4

Solution – roztwór

A homogenous mixture. Solutions can be solids, liquids, or gases.
A solution consists of a solute and a solvent.



Primary terms

solute	**substancja rozpuszczona**
def.	The substance dissolved in a solvent in forming a solution. It is normally the component of a solution present in the smaller amount. For example, when a small amount of sodium chloride, NaCl, is mixed with a large quantity of water, we refer to sodium chloride as the solute.
↔	solvent
↓	concentration, dissociation, electrolyte, hydrolysis, neutralization reaction, saturated solution, solubility

solvent	**rozpuszczalnik**
def.	A liquid that dissolves another substance or substances to form a solution. It is normally the component of a solution present in the greater amount. For example, when a small amount of sodium chloride, NaCl, is mixed with a large quantity of water, we refer to water as the solvent.
↔	solute
↓	concentration, electrolyte, hydrolysis, saturated solution, solubility

First-order derivative terms

concentration	**stężenie**
def.	The quantity of dissolved substance per unit quantity of a solution. The greater the amount of solute that is dissolved in a certain amount of solvent, the more concentrated the resulting concentration. Many properties of solutions depend directly on their concentrations.
↑	solute, solvent
↔	solubility
↓	amount concentration, pH, pOH, solubility product

dissociation	**dysocjacja**
def.	A chemical process whereby ionic compounds break down into smaller molecules, ions, etc. Acids, bases, and salts dissociate in water. Dissociation often results in a change in the pH. For example, $HCN(aq) \rightarrow H^{+}(aq) + CN^{-}(aq)$
↑	solute
↔	electrolyte, hydrolysis, neutralisation reaction
↓	acid dissociation constant, autoionization, base dissociation constant, buffer, pH, pOH

electrolyte	**elektrolit**
def.	A substance whose aqueous solutions contain ions and hence conducts electricity. Essentially, all ionic compounds (such as NaCl) and a few molecular compounds (such as HCl) exist in solution completely or nearly completely as ions.
↑	solute, solvent
↔	dissociation

hydrolysis	**hydroliza**
def.	A chemical reaction of a compound with water whereby H^+ or OH^- ions are generated For example, salts of weak acids or bases hydrolyse in aqueous solution, as in: $Na^+CH_3COO^-(aq) + H_2O(l) \rightarrow Na^+(aq) + OH^-(aq) + CH_3COOH(aq)$
↑	solute, solvent
↔	dissociation, neutralisation reaction
↓	pH, pOH

neutralisation reaction	**reakcja zobojętniania** **= reakcja neutralizacji**
def.	A reaction which occurs when a solution of an acid and that of a base are mixed. The products of the reaction have none of the properties of either the acidic or basic solutions. For example, when hydrochloric acid, HCl, is mixed with a solution of sodium hydroxide, NaOH, the following reaction occurs: $HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$
↑	solute
↔	dissociation, hydrolysis
↓	pH, pOH

saturated solution	**roztwór nasycony**
def.	A solution containing the maximum equilibrium amount of a solute at a given temperature. In saturated solution, the dissolved substance is dissolved with undissolved substance; i.e. the rate at which solute particles leave the solution is exactly balanced by the rate at which they dissolve.
↑	solute, solvent
↔	solubility
↓	molar solubility, solubility product, precipitation

solubility	**rozpuszczalność**
def.	The quantity of solute that dissolves in a given quantity of solvent to form a saturated solution. The solubility of a substance in a given solvent depends on the temperature. Generally, for a solid in a liquid, solubility increases with temperature; for a gas, solubility decreases.
↑	solute, solvent
↔	concentration, saturated solution
↓	molar solubility, solubility product, precipitation

Second-order derivative terms

acid dissociation constant **= acidity constant**	**stała dysocjacji kwasowej** **= stała dysocjacji kwasu, stała kwasowości**
def.	Symbol (K_a). A measure of the strength of an acid. It expresses the extent to which an acid transfers a proton to solvent water. For the dissociation of hydrocyanic acid, HCN, it is given by $K_a=[H^+][CN^-]/[HCN]$
↑	dissociation
↔	base dissociation constant, pH

amount concentration **= amount-of-substance concentration**	**stężenie ilości substancji** **= stężenie molowe**
def.	Symbol (c). The amount of substance dissolved per unit volume of the solution. Amount concentration has units mol dm^{-3}. A 1.00 molar solution, written 1.00 M, contains 1.00 mol of solute in every litre of solution.
↑	concentration, electrolyte
↔	pH, pOH

autoionization **= self-ionization, autodissociation**	**autojonizacja** **= autodysocjacja**
def.	The process whereby water spontaneously forms low concentrations of H^+ and OH^- ions by proton transfer from one water molecule to another. Autoionization can be represented by the following reaction: $H_2O(l) \rightarrow H^+(aq) + OH^-(aq)$
↑	dissociation
↔	pH, pOH

base dissociation constant **= basicity constant**	**stała dysocjacji zasadowej** **= stała dysocjacji zasady,** **stała zasadowości**
def.	Symbol (K_b). A measure of the stength of a base. It expresses the extent to which a base reacts with solvent water, accepting a proton and forming OH^-. For the dissociation of ammonia, NH_3, it is given by $K_b=[NH_4^+][OH^-]/[NH_3]$
↑	dissociation
↔	acid dissociation constant, pOH

buffer **= buffer solution**	**bufor** **= roztwór buforowy**
def.	A solution that resists change in pH when an acid or alkali is added or when the solution is diluted. Acid buffers consist of a weak acid with salt of the acid. An example is carbonic acid, H_2CO_3, and sodium hydrogencarbonate, $NaHCO_3$. Basic buffers have a weak base and a salt of the base. An example is ammonia solution, NH_3, with ammonium chloride, NH_4Cl.
↑	dissociation
↔	pH, pOH

molar solubility	**rozpuszczalność molowa**
def.	Symbol (S). A measure of the solubility of a substance. Molar solubility is the number of moles of the solute that dissolve in forming a litre of the solute. It changes as the concentrations of other solutes change.
↑	saturated solution
↔	precipitation, solubility product

pH	**pH**
def.	A measure of the concentration of H^+ in a solution. It is equal to $-\log[H^+]$. A neutral solution at 25°C has a hydrogen ion concentration of 10^{-7} mol dm^{-3}, so the pH is 7. A pH below 7 indicates an acidic solution, one above 7 indicates a basic solution.
↑	concentration, dissociation, hydrolysis, neutralization reaction
↔	acid dissociation constant, amount concentration, autoionization, buffer, pOH

pOH	**pOH**
def.	A measure of the concentration of OH^- in a solution. It is equal to $-\log[OH^-]$. A neutral solution at 25°C has a hydroxide ion concentration of 10^{-7} mol dm^{-3}, so the pOH is 7. A pOH below 7 indicates a basic solution, one above 7 indicates an acidic solution.
↑	concentration, dissociation, hydrolysis, neutralization reaction
↔	amount concentration, autoionization, base dissociation constant, buffer, pH

precipitation	**strącanie**
def.	The formation of an insoluble compound from solution either by interaction of two salts, for example $NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(s)$ or by temperature change affecting solubility.
↑	saturated solution, solubility
↔	molar solubility

solubility product	**iloczyn rozpuszczalności**
def.	Symbol (K_s). The product of the concentrations of ions in a saturated solution. For instance, if a compound A_xB_y is in equilibrium with its solution $A_xB_y \leftrightarrow xA^+ + yB^-$ the solubility product can be given by $K_s = [A^+]^x[B^-]^y$. If the product of ionic concentrations in a solution exceeds the solubility product, then precipitation occurs.
↑	concentration, saturated solution, solubility
↔	molar solubility, precipitation

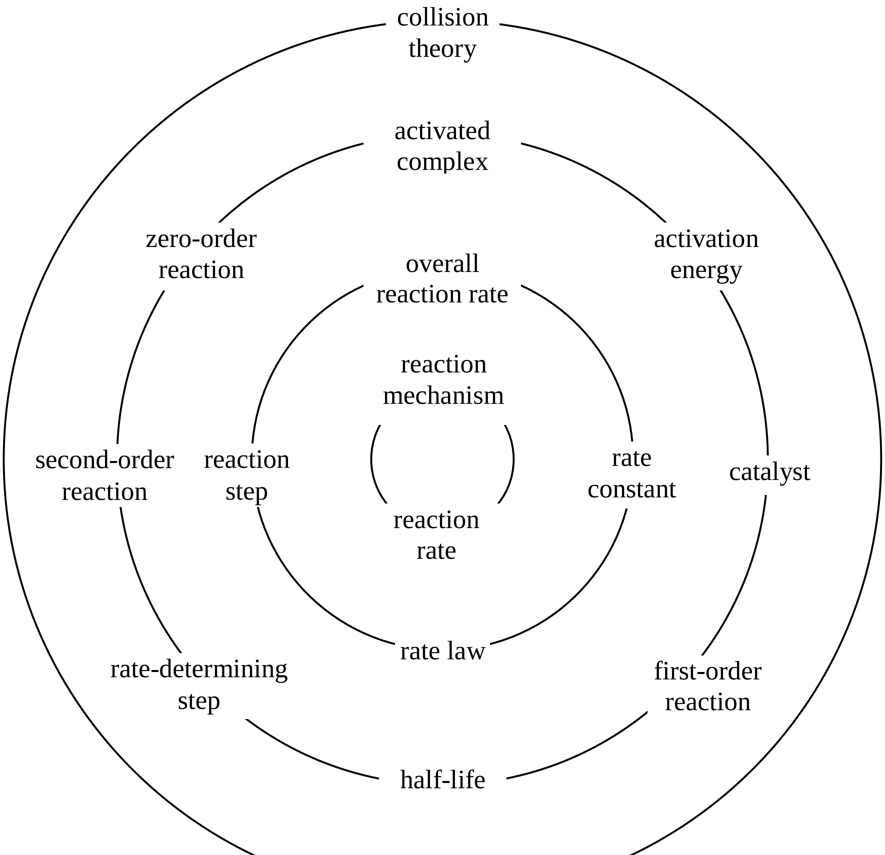
Key terms

Ostwald's dilution law	**prawo rozcieńczeń Ostwalda**
def.	An expression for the degree of dissociation of a weak electrolyte. For example, if a weak acid dissociates in water $HA \rightarrow H^+ + A^-$ the dissociation constant K_a is given by $K_a = \alpha^2 n/(1-\alpha)V$ where α is the degree of dissociation, n the initial amount of substance, and V the volume.
< >	acid dissociation constant, base dissociation constant, dissociation, pH, pOH

Module 5

Chemical kinetics – kinetyka chemiczna

The branch of chemistry concerned with the mechanisms and rates of chemical reactions. Chemical kinetics includes investigations into how different conditions (temperature, pressure, etc.) affect the reaction rate.



Primary terms

reaction mechanism	**mechanizm reakcji**
def.	A sequence of steps during which a reaction occurs, that is the order in which bonds are broken and formed, and the changes in relative positions of the atoms as the reaction proceeds.
↔	reaction rate
↓	overall reaction order, reaction step

reaction rate	**szybkość reakcji**
def.	The decrease in concentration of a reactant or the increase in concentration of a product with time. Reaction rates are usually expressed as changes in concentration per unit time.
↔	reaction mechanism
↓	overall reaction order, rate constant, rate law

First-order derivative terms

overall reaction order	**całkowity rząd reakcji**
def.	The sum of the powers of the concentrations in the expression for the rate of a chemical reaction. For example, in a reaction $A + B \rightarrow C$ the rate law may have the form rate = $k[A][B]^2$. The overall reaction order is therefore three. Reaction orders must be determined experimentally.
↑	reaction mechanism, reaction rate
↔	rate law, reaction step
↓	first-order reaction, half-life, second-order reaction, zero-order reaction

rate constant **= rate coefficient**	**stała szybkości** **= współczynnik szybkości**
def.	Symbol (k). A constant of proportionality between the reaction rate and the concentrations of reactants that appear in the rate law. For example, in a simple reaction $A \rightarrow B$, the rate is proportional to the concentration of A, i.e. rate = $k\,[A]$, where k is the rate constant that depends on the temperature.
↑	reaction rate
↔	rate law
↓	activated complex, activated energy, catalyst, half-life

rate law **= rate equation**	**prawo szybkości** **= równanie szybkości reakcji, równanie kinetyczne**
def.	An equation that relates the reaction rate to the concentrations of reactants of reactants and sometimes of products. It usually has the following form: $\text{Rate} = k[\text{reactant 1}]^m[\text{reactant 2}]^n \ldots$ The constant k is called rate constant, m, n, and so forth are constant exponents. The sum m + n + … is called the overall reaction order.
↑	reaction rate
↔	overall reaction order, rate constant
↓	catalyst

reaction step	**etap reakcji**
def.	Processes in a chemical reaction that occur in a single event. Each step has a well-defined rate-law that depends on the number of molecules of the step.
↑	reaction mechanism
↔	overall reaction order
↓	rate-determining step

Second-order derivative terms

activated complex	**kompleks aktywny**
def.	The particular arrangement of atoms found at the top of the potential-energy barrier as a reaction proceeds from reactants to products. In order for the activated complex to be reached, the collision must be energetic enough and the reactants must be correctly oriented.
↑	rate constant
↔	activation energy, catalyst, rate-determining step

activation energy	**energia aktywacji**
def.	Symbol (E_a). The minimum energy required for a chemical reaction to take place. The activation energy determines the way in which the rate of the reaction varies with temperature.
↑	rate constant
↔	activated complex, catalyst

catalyst	**katalizator**
def.	A substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change. The catalyst provides an alternative pathway by which the reaction can proceed, in which the activation energy is lower.
↑	rate constant, rate law
↔	activated complex, activated energy

first-order reaction	**reakcja pierwszego rzędu**
def.	A reaction in which the reaction rate is proportional to the concentration of a single reactant, raised to the first power, that is rate = k[A]. An example is $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$.
↑	overall reaction order
↔	half-life, second-order reaction, zero-order reaction

half-life	**okres półtrwania** **= okres połowicznego zaniku**
def.	Symbol ($t_{1/2}$). The time required for the concentration of a reactant substance to decrease to half of its initial value. For a first-order reaction, the half-life depends only on the rate constant and not on the initial concentration: $t_{1/2} = 0.693/k$.
↑	overall reaction order, rate constant
↔	first-order reaction, second-order reaction, zero-order reaction

rate-determining step **= rate-limiting step**	**etap determinujący szybkość** **= etap limitujący szybkość**
def.	The slowest elementary step in a chemical reaction that involves a number of steps. In such reactions, there is often a single step that is significantly slower than the other steps, and the rate of this determines the overall rate of the reaction.
↑	reaction step
↔	activated complex

second-order reaction	**reakcja drugiego rzędu**
def.	A reaction in which the overall reaction order in the rate law is two. A second-order reaction may depend on the concentrations of one second-order reactants, or two first-order reactants, that is rate = $k[A]^2$, or rate = k[A][B]. An example is $2NO_2(g) \rightarrow 2NO(g) + O_2(g)$.
↑	overall reaction order
↔	first-order reaction, half-life, zero-order reaction

zero-order reaction	**reakcja zerowego rzędu**
def.	A reaction for which reaction rate is independent of the concentrations of the reactants. Consequently, increasing the concentration of the reacting species will not speed up the rate of the reaction. The rate law for a zero-order reaction is rate = k. An example is: $2NH_3(g) \rightarrow 3H_2(g) + N_2(g)$.
↑	overall reaction order
↔	first-order reaction, half-life, second-order reaction

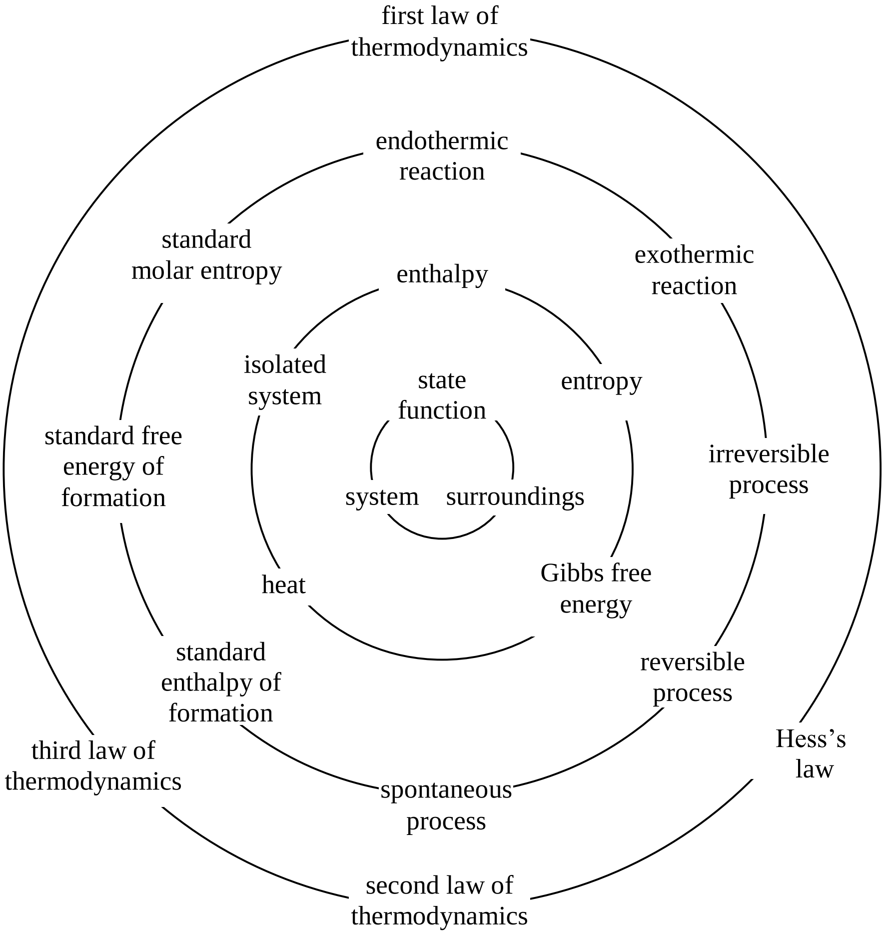
Key terms

collision theory	**teoria zderzeń**
def.	A theory based on the idea that molecules must collide to react. It explains the factors influencing reaction rates in terms of the frequency of collisions, the number of collisions with energies exceeding the activation energy, and the probability that the collisions occur with suitable orientation. The theory was proposed by Max Trautz and William Lewis in 1916 and 1918.
< >	activated complex, activation energy, first-order reaction, rate law, second-order reaction, zero-order reaction

Module 6

Chemical thermodynamics – termodynamika chemiczna

The branch of chemistry that studies the transformation of one type of energy into other types as well as the interelation of heat and work with chemical reactions or with physical changes.



Primary terms

state function	**funkcja stanu**
def.	A property of a system that is determined by the state or condition of the system and not by how it got to that state. Its value is fixed when temperature, pressure, composition, and physical form are specified.
↔	system
↓	enthalpy, entropy, Gibbs free energy, heat

surroundings	**otoczenie**
def.	Everything that lies outside the system under study.
↔	system
↓	isolated system

system	**układ**
def.	The portion of the universe that is singled out for study.
↔	state function, surroundings
↓	enthalpy, entropy, Gibbs free energy, heat, isolated system

First-order derivative terms

enthalpy	**entalpia**
def.	Symbol (H). A thermodynamic property of a system defined by $H = U + pV$, where H is the enthalpy, U is the internal energy of the system, p its pressure, and V its volume. The enthalpy change, ΔH, it is the heat absorbed or evolved in a reaction.
↑	state function, system
↔	entropy, Gibbs free energy, heat, isolated system
↓	endothermic reaction, exothermic reaction, standard enthalpy of formation

entropy	**entropia**
def.	Symbol (S). A measure of a system’s unavailability to do work. Entropy is related to randomness or disorder. The greater the disorder, the greater the entropy.
↑	state function, system
↔	enthalpy, Gibbs free energy, isolated system
↓	standard molar entropy

Gibbs free energy **= Gibbs function**	**entalpia swobodna** **= funkcja Gibbsa**
def.	Symbol (G). A measure of a system's ability to do work. The Gibbs free energy is defined by $G = H - TS$, where G is the energy liberated or absorbed in a reversible process at constant pressure and constant temperature (T), H is the enthalpy and S the entropy. Changes in Gibbs free energy, ΔG, are useful in indicating the conditions under which a chemical reaction will occur.
↑	state function, system
↔	enthalpy, entropy
↓	irreversible process, reversible process, spontaneous process, standard free energy of formation

heat	**ciepło**
def.	Symbol (q) or (Q). The flow of energy from a body at a higher temperature to one at lower temperature when they are placed in thermal contact. In chemistry, heat is commonly measured in calories.
↑	state function, system
↔	enthalpy, isolated system
↓	endothermic reaction, exothermic reaction

isolated system	**układ izolowany**
def.	A system that does not exchange energy or matter with its surroundings. Any process that occurs in an isolated system leaves the surroundings completely unchanged. Therefore, the change in entropy of the surroundings equals zero.
↑	surroundings, system
↔	enthalpy, entropy, heat, isolated system

Second-order derivative terms

endothermic reaction	**reakcja endotermiczna**
def.	A reaction in which heat is absorbed. For an endothermic reaction the enthalpy change, ΔH, is taken to be negative. According to the laws of thermodynamics a spontaneous endothermic reaction must be accompanied by an increase in entropy of the system and surroundings. An example is $CO_2(g) + 2H_2O(l) \rightarrow CH_4(g)+ 2O_2(g)$.
↑	enthalpy, heat
↔	exothermic reaction

exothermic reaction	**reakcja egzotermiczna**
def.	A reaction in which heat is produced. For an exothermic reaction the enthalpy change, ΔH, is taken to be negative. An example is $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$
↑	enthalpy, heat
↔	endothermic reaction

irreversible process	**proces nieodwracalny**
def.	Any process in which the variables that define the state of the system cannot be made to change in such a way that they pass through the same values in the reverse order when the process is reversed. Any spontaneous process is irreversible. An example is placing one mol of ice in laboratory at room temperature.
↑	Gibbs free energy
↔	reversible process

reversible process	**process odwracalny**
def.	Any process in which the variables that define the state of the system can be made to change in such a way that they pass through the same values in the reverse order when the process is reversed. An example is the melting and freezing of water at 0°C.
↑	Gibbs free energy
↔	irreversible process

spontaneous process	**proces spontaniczny**
def.	Any process that is capable of proceeding in a given direction, as written or described, without needing to be driven by an outside source of energy. A process may be spontaneous even though it is very slow. An example is $2O_3(g) \rightarrow 3O_2(g)$.
↑	Gibbs free energy

standard enthalpy of formation	**standardowa entalpia tworzenia**
def.	Symbol (ΔH_f). The change in enthalpy that accompanies the formation of 1 mole of a substance from its elements, with all substances in their standard states. The standard enthalpy of formation of the most stable form of any element is zero.
↑	enthalpy
↔	standard free energy of formation, standard molar entropy

standard free energy of formation	**standardowa entalpia swobodna tworzenia**
def.	Symbol (ΔG_f°). The change in free energy associated with the formation of a substance from its elements under standard conditions. The free energies of elements in their standard states are set to zero.
↑	Gibbs free energy
↔	standard enthalpy of formation, standard molar entropy

standard molar entropy	**standardowa entropia molowa**
def.	Symbol (S°).The entropy value for a mole of a substance in its standard state. The standard entropies of gases are greater than those of liquids and solids. The standard molar entropies of elements are zero.
↑	entropy
↔	standard enthalpy of formation, standard free energy of formation

Key terms

first law of thermodynamics	**pierwsza zasada termodynamiki**
def.	A law stating that energy is conserved in any process. The first law can be expressed in many ways. One of the more useful expressions is that the change in internal energy, ΔE, of a system in any process is equal to heat, q, added to the system, plus the work, w, done on the system by its surroundings: $\Delta E = q + w$. The first law of thermodynamics was stated by Rudolf Clausius in 1850.
↔	Hess’s law, second law of thermodynamics, third law of thermodynamics
< >	heat, enthalpy

Hess’s law	**prawo Hessa**
def.	A chemical law stating that the heat evolved in a given process can be expressed as the sum of heats of several processes that, when added, yield the process of interest. More generally, the overall energy change in going from reactants to products does not depend on the route taken. The law can be used to obtain thermodynamic data that cannot be measured directly. The law was first put forward in 1840 by Germain Henri Hess.
↔	first law of thermodynamics
< >	enthalpy, heat

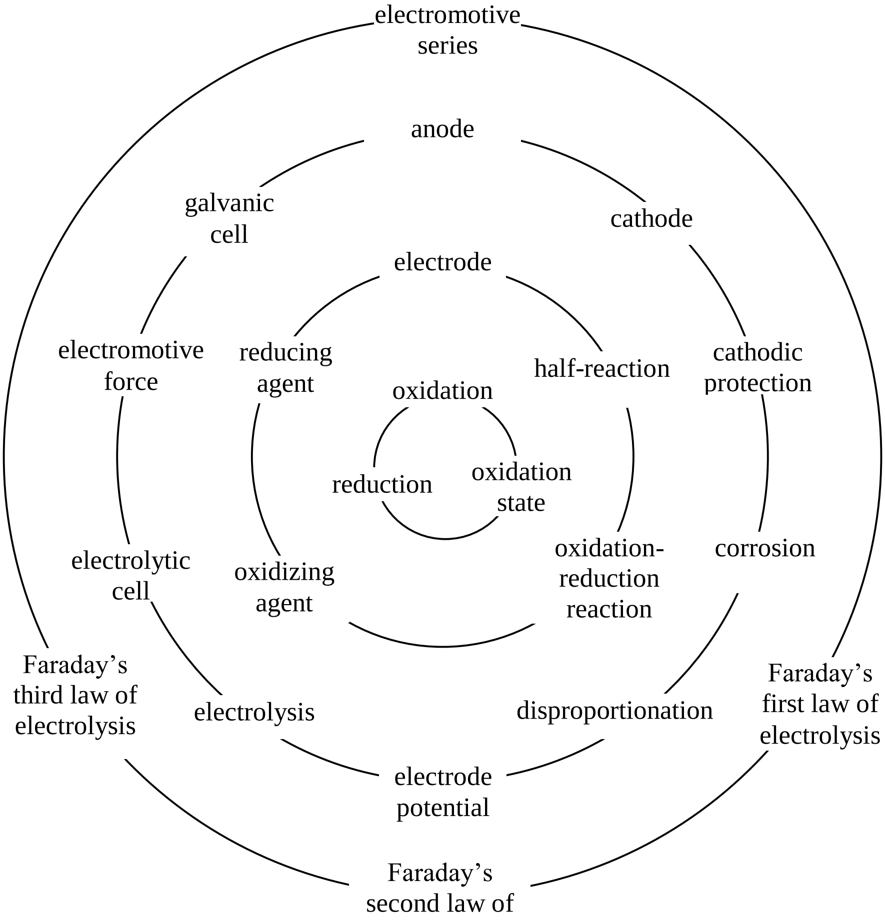
second law of thermodynamics	**druga zasada termodynamiki**
def.	A law stating that there is a direction to the way events occur in nature. When a process occurs spontaneously in one direction, it is not spontaneous in the reverse direction. The second law of thermodynamics was stated by Rudolf Clausius in 1854.
↔	first law of thermodynamics, third law of thermodynamics
< >	entropy, Gibbs free energy, spontaneous process

third law of thermodynamics	**trzecia zasada termodynamiki**
def.	A law stating that the entropy of a pure, crystalline solid at absolute zero temperature is zero: $S(0K) = 0$. This law provides an absolute scale of values for entropy. The third law of thermodynamics was developed by Walther Nernst during the years 1906–1912.
↔	first law of thermodynamics, second law of thermodynamics
< >	entropy

Module 7

Electrochemistry – elektrochemia

The branch of chemistry that studies the relationships between electricity and chemical reactions. It studies spontaneous as well as nonspontaneous processes.



Primary terms

oxidation	**utlenienie** **= oksydacja**
def.	A process in which a substance loses one or more electrons. For example, in the process: $Sn^{2+}(aq) \rightarrow Sn^{4+}(aq) + 2e^{-}$ the Sn^{2+} ion loses two electrons to give Sn^{4+} ions and is oxidized.
↔	oxidation state, reduction
↓	electrode, half-reaction, oxidation-reduction reaction, oxidizing agent

oxidation state	**stopień utlenienia**
def.	A positive or negative number assigned to an element in a molecule or ion on the basis of a set of formal rules. To some degree, it reflects the positive or negative character of that atom. For example, in Fe^{3+} iron has an oxidation number +3.
↔	oxidation, reduction
↓	half-reaction, oxidation-reduction reaction

reduction	**redukcja**
def.	A process in which a substance gains one or more electrons. For example, in the process $Fe^{3+}(aq) + e^{-} \rightarrow Fe^{2+}(aq)$ the Fe^{3+} ion gains one electron and is reduced.
↔	oxidation, oxidation state
↓	electrode, half-reaction, oxidation-reduction reaction, reducing agent

First-order derivative terms

electrode	**elektroda**
def.	A conductor that emits or collects electrons in a cell, thermionic valve, semiconductor device, etc. Electrodes can be divided into anodes and cathodes.
↑	oxidation, reduction
↔	half-reaction
↓	anode, cathode, cathodic protection, electrode potential, electrolysis, electrolytic cell, electromotive force, galvanic cell

half-reaction	**reakcja połówkowa**
def.	An equation for either an oxidation or a reduction that shows the electrons involved. In the oxidation process electrons are shown as products; in the reduction process electrons are shown on the reactant side of the equation For example, $Sn^{2+}(aq) \rightarrow Sn^{4+}(aq) + 2e^{-}$ or $Fe^{3+}(aq) + e^{-} \rightarrow Fe^{2+}(aq)$
↑	oxidation, oxidation state, reduction
↔	electrode, oxidation-reduction reaction
↓	anode, cathode, electrode potential

oxidation-reduction reaction = redox reaction	**reakcja utleniania i redukcji = reakcja redoks**
def.	A reaction in which certain atoms undergo changes in oxidation states. The substance increasing in oxidation state is oxidized, the substance decreasing in oxidation state is reduced. An example is the oxidation of Sn^{2+} by Fe^{3+}: $2Fe^{3+}(aq) + Sn^{2+} \rightarrow 2Fe^{2+}(aq) + Sn^{4+}(aq)$
↑	oxidation, oxidation state, reduction
↔	half-reaction
↓	corrosion, disproportionation, electrolysis, electrolytic cell, electromotive force, galvanic cell

oxidizing agent = oxidant	**utleniacz**
def.	A substance that brings about oxidation in other substances. It achieves this by being itself reduced. Oxidizing agents contain atoms in high oxidation states. In oxidizing other substances these atoms gain electrons. For example, in the reaction $2Fe^{3+}(aq) + Sn^{2+}(aq) \rightarrow 2Fe^{2+}(aq) + Sn^{4+}(aq)$ the Fe^{3+} ion is the oxidizing agent.
↑	oxidation
↔	reducing agent
↓	cathodic protection

reducing agent = reductant	**reduktor**
def.	A substance that brings about reduction in other substances. It achieves this by being itself oxidized. Reducing agents contain atoms in low oxidation states. In reducing other substances these atoms lose electrons. For example, in the reaction $2Fe^{3+}(aq) + Sn^{2+}(aq) \rightarrow 2Fe^{2+}(aq) + Sn^{4+}(aq)$ the Sn^{2+} ion is the reducing agent.
↑	reduction
↔	oxidizing agent

Second-order derivative terms

anode	**anoda**
def.	An electrode at which oxidation occurs.
↑	electrode, half-reaction
↔	cathode, electrode potential

cathode	**katoda**
def.	An electrode at which reduction occurs.
↑	electrode, half-reaction
↔	anode, cathodic protection, electrode potential

cathodic protection **= sacrificial protection**	**ochrona katodowa**
def.	The protection of iron or steel against corrosion by using a more reactive metal. A common form is galvanizing, in which the iron surface is coated with a layer of zinc.
↑	electrode, oxidizing agent
↔	cathode, corrosion

corrosion	**korozja**
def.	The process by which a metal is oxidized by substances in its environment and converted to an unwanted compound. The corrosion of iron into rust is caused by the presence of water and oxygen, and is accelerated by the presence of electrolytes.
↑	oxidation-reduction reaction
↔	cathodic protection

disproportionation	**dysproporcjonowanie**
def.	A type of chemical reaction in which the same compound is simultaneously reduced and oxidized. For example, copper(I) chloride disproportionates $2CuCl \rightarrow Cu + Cl_2$ thus the reaction involves oxidation of one molecule $Cu^{+}(aq) \rightarrow Cu^{2+}(aq) + e^{-}$ and reduction of the other $Cu^{+}(aq) + e^{-} \rightarrow Cu(s)$.
↑	oxidation-reduction reaction

electrode potential **= reduction potential**	**potencjał elektrody** **= potencjał redukcyjny**
def.	Symbol (E). A measure of the driving force for the completion of an electrochemical reaction. It is measured in volts. For a reduction half-reaction, it is a measure of the tendency of the reduction to occur. Fluorine, F_2, has the most positive value of E.
↑	electrode, half-reaction
↔	anode, cathode, electromotive force

electrolysis	**elektroliza**
def.	The production of a chemical reaction by passing an electric current through an electrolyte. In electrolysis, positive ions migrate to the cathode and negative ions to the anode. The reactions occurring depend on electron transfer at the electrodes and are therefore redox reactions. The anode reactions are oxidations and cathode reactions are reductions.
↑	electrode, oxidation-reduction reaction
↔	electrolytic cell

electrolytic cell	**ogniwo elektrolityczne**
def.	A device in which a nonspontaneous oxidation-reduction is caused to occur by passage of current. The cathode is negative and the anode is positive. The electrodes can be involved in the electrolysis reaction.
↑	electrode, oxidation-reduction reaction
↔	electrolysis, electromotive force, galvanic cell

electromotive force	**siła elektromotoryczna**
def.	Symbol (E) or (emf). The greatest potential difference that can be generated by a particular source of electric current. In practice this may be observable only when the source is not supplying current, because of its internal resistance.
↑	electrode, oxidation-reduction reaction
↔	electrode potential, electrolytic cell, galvanic cell

galvanic cell **= voltaic cell**	**ogniwo galwaniczne** **= ogniwo Volty**
def.	A device in which a spontaneous oxidation-reduction reaction occurs with the passage of electrons through an external circuit. The cathode is positive and the anode is negative.
↑	electrode, oxidation-reduction reaction
↔	electrolytic cell, electromotive force

Key terms

electromotive series **= electrochemical series**	**szereg napięciowy** **= szereg elektrochemiczny**
def.	A series of chemical elements arranged in order of their electrode potentials. The series shows the order in which metals replace one another from their salts.
↔	Nernst equation
< >	electrode, oxidation-reduction reaction,

Faraday's first law of electrolysis	**pierwsze prawo elektrolizy Faraday'a**
def.	A chemical law stating that the amount of chemical change during electrolysis is proportional to the charge passed. The law was stated by Michael Faraday.
↔	Faraday's second law of electrolysis
< >	electrolysis, electrolytic cell

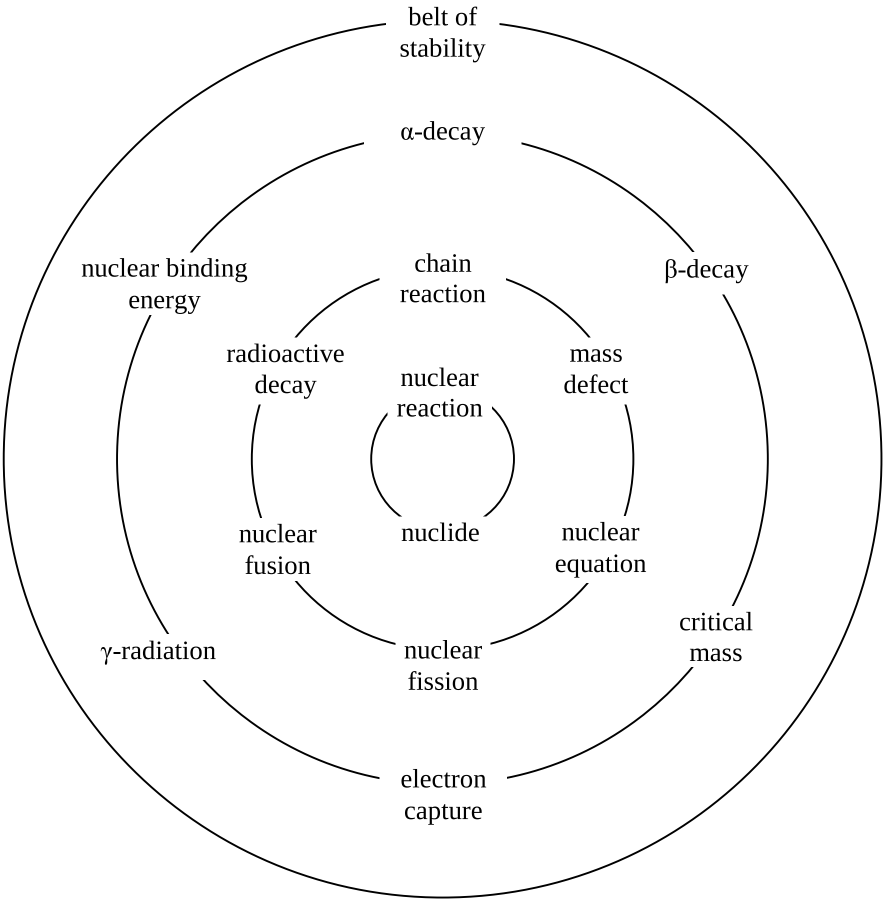
Faraday's second law of electrolysis	**drugie prawo elektrolizy Faraday'a**
def.	A chemical law stating that the charge required to deposit or liberate a mass m is given by Q = Fmz/M, where F is the Faraday constant (96,500 C/mol e^{-}), z is the charge of the ion, and M the relative ionic mass. The law was stated by Michael Faraday.
↔	Faraday's first law of electrolysis
< >	electrolysis, electrolytic cell

Nernst equation	**równanie Nernsta**
def.	An equation that relates the electrode potential E of an electrode that is in contact with an ionic solution to the ionic concentration c. The equation is: $E = E^{\circ} – RTzFln\ c$, where E° is the standard electrode potential, R is the gas constant, T is the absolute temperature, z is the charge of the ion, and F is the Faraday constant (96,500 C/mol e^{-}). The equation was derived by Walther Nernst in 1889.
↔	electromotive series
< >	electrode, electrode potential, electromotive force

Module 8

Nuclear chemistry – chemia jądrowa

The branch of chemistry concerned with nuclear reactions.
It focuses on the study of radioactive elements, especially their nuclei.



Primary terms

nuclear reaction	**reakcja jądrowa**
def.	A change in matter originating in the nucleus of an atom. Nuclear reactions differ from chemical reactions, in which electrons play a dominant role. Nuclear reactions are used both to generate electricity and to create weapons of mass destruction.
↔	nuclide
↓	chain reaction, nuclear equation, nuclear fission, nuclear fusion, radioactive decay

nuclide	**nuklid**
def.	A type of atom as characterized by its atomic number and its neutron number. An isotope refers to a series of different atoms that have the same atomic number but different neutron numbers, whereas a nuclide refers only to a particular nuclear species.
↔	nuclear reaction
↓	mass defect, nuclear fission, nuclear fusion, radioactive decay

First-order derivative terms

chain reaction	**reakcja łańcuchowa**
def.	A reaction that is self-sustaining as a result of the products of one step initiating a subsequent step. The term can be applied to the fusion of light isotopes and the fission of heavy isotopes.
↑	nuclear reaction
↔	nuclear fission, nuclear fusion
↓	critical mass

mass defect **= mass deficiency**	**defekt masy** **= deficyt masy, niedobór masy**
def.	The difference between the between the mass of a nucleus and the total masses of the individual nucleons that it contains. The mass defect of a nuclide allows the calculation of its nuclear binding energy.
↑	nuclide
↔	nuclear fission, nuclear fusion
↓	nuclear binding energy

nuclear equation	**równanie reakcji jądrowej**
def.	A type of equation that is used to represent nuclear reactions. Every particle is shown with the mass number and the atomic number. The sum of the mass numbers is equal on both sides of the equation. The same applies to the sum of the atomic numbers.
↑	nuclear reaction
↔	nuclear fission, nuclear fusion, radioactive decay

nuclear fission	**rozszczepienie jądrowe** **= rozszczepienie jądra atomu**
def.	The splitting of a large nucleus into two smaller ones. Fission of heavy elements is an exothermic process. An example is: ${}^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{142}_{56}\mathrm{Ba} + {}^{91}_{36}\mathrm{Kr} + 2\,{}^{1}_{0}\mathrm{n}$.
↑	nuclear reaction, nuclide
↔	chain reaction, mass defect, nuclear fusion, radioactive decay, nuclear equation
↓	critical mass, nuclear binding energy

nuclear fusion	**synteza jądrowa** **= fuzja jądrowa**
def.	The joining of two light nuclei to form a more massive one. Fusion of light nuclei is an exothermic process. Reactions of this type are responsible for the energy produced by the Sun. Most fusion products are not radioactive. An example is: ${}^{1}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{2}_{1}\mathrm{H} + {}^{0}_{1}\mathrm{e}$.
↑	nuclear reaction, nuclide
↔	chain reaction, mass defect, nuclear fission, radioactive decay, nuclear equation
↓	nuclear binding energy

radioactive decay	**rozpad promieniotwórczy**
def.	The spontaneous transformation of one nuclide into a daughter nuclide, which may be radioactive or not, with the emission of one or more particles or photons. It is a first-order process. Nuclides that undergo radioactive decay have consequently constant half-lives.
↑	nuclear reaction, nuclide
↔	nuclear fission, nuclear fusion, nuclear equation
↓	α-decay, β-decay, electron capture, γ-radiation

Second-order derivative terms

α-decay **= alpha-decay**	**rozpad α** **= rozpad alfa**
def.	A type of radioactive decay in which an alpha particle (i.e. a helium-4 nucleus) is emitted. When for example a uranium-238 nucleus loses an alpha particle, the remaining fragment has an atomic number of 90 and a mass number of 234. It is therefore a thorium-234 nucleus. This reaction can be represented by the following nuclear equation: ${}^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$
↑	radioactive decay
↔	β-decay, electron capture, γ-radiation

β-decay **= beta-decay**	**rozpad β** **= rozpad beta**
def.	A type of radioactive decay in which a beta particle (i.e. an electron) is emitted. When for example iodine-131 emits an electron, the remaining fragment has an atomic number of 54 and a mass number of 131. It is therefore a xenon-131 nucleus. This reaction can be represented by the following nuclear equation: ${}^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}\mathrm{e}$.
↑	radioactive decay
↔	α-decay, electron capture, γ-radiation

critical mass	**masa krytyczna**
def.	The amount of fissionable material able to maintain a chain reaction with a constant rate of fission. When a critical mass of material is present, only one neutron from each fission is subsequently effective in producing another fission.
↑	chain reaction, nuclear fission

electron capture	**wychwyt elektronu**
def.	A type of radioactive decay in which an inner-shell electrons is captured by the nucleus from the electron cloud surrounding the nucleus. When for example rubidium-81 undergoes decay in this way, it transforms into krypton-81. This reaction can be represented by the following nuclear equation: ${}^{81}_{37}\mathrm{Rb} + {}^{0}_{-1}\mathrm{e} \rightarrow {}^{81}_{36}\mathrm{Kr}$.
↑	radioactive decay
↔	α-decay, β-decay, γ-radiation

γ-radiation **= gamma radiation, γ-decay, gamma-decay**	**promieniowanie γ** **= promieniowanie gamma, rozpad γ, rozpad gamma**
def.	A type of radioactive decay in which high-energy photons are emitted. Gamma-decay changes neither the atomic number nor the mass number of a nucleus. It almost always accompanies other radioactive emission.
↑	radioactive decay
↔	α-decay, β-decay, electron capture

nuclear binding energy	**energia wiązania jądra**
def.	The energy required to separate a nucleus into its individual nucleons. The larger the binding energy, the more stable the nucleus toward decomposition.
↑	mass defect, nuclear fission, nuclear fusion

Key terms

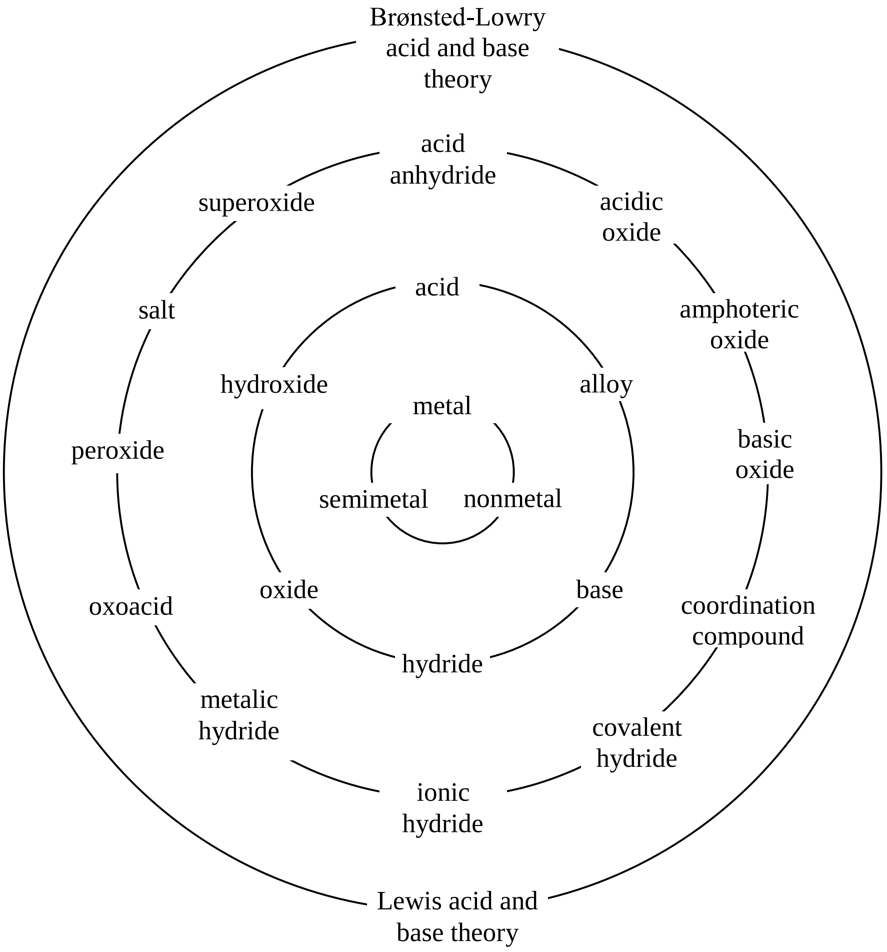
band of stability	**przedział trwałości**
def.	The range of the number of neutrons versus number of protons for stable nuclei graph that plots all stable nuclei. The band of stability can be used to determined what type of radioactive decay a particular nuclide undergoes. Nuclei above the band of stability undergo beta-decay. For nuclei below the band of stability electron capture is common. Nuclei with atomic numbers ≥ 84 undergo alpha-decay.
↔	radioactive series
< >	radioactive decay

radioactive series	**szereg promieniotwórczy** **= rodzina promieniotwórcza**
def.	A series of nuclear reactions that begins with an unstable nucleus and terminates with a stable one. Three such series occur in nature. One of them begins with uranium-238 and terminates with lead-206.
↔	band of stability
< >	radioactivity series

Module 9

Inorganic chemistry – chemia nieorganiczna

The branch of chemistry concerned with elements and compounds of elements other than carbon. Certain simple carbon compounds, such as CO_2*,* CO*,* H_2CO_3 *and its salts, are usually treated in inorganic chemistry.*



Primary terms

metal	**metal**
def.	An element that forms positive ions in chemical reactions. Typically, they are lustrous solids that are good conductors of heat and electricity. All metals have oxides that are basic, although some, such as aluminium have amphoteric properties. For example, iron is a metal.
↔	nonmetal, semimetal
↓	acid, alloy, base, hydride, oxide, hydroxide

nonmetal	**niemetal**
def.	An element that generally forms negative ions in chemical reactions. Typically, nonmetals are poor conductors of both heat and electricity. Their oxides are either neutral or acidic. For example, oxygen is a nonmetal.
↔	metal, semimetal
↓	acid, alloy, base, hydride, oxide, hydroxide

semimetal **= metalloid**	**półmetal** **= metaloid**
def.	An element that is intermediate in properties between metals and nonmetals. They are electrical semiconductors and their oxides are amphoteric. For example, arsenic is a semimetal.
↔	metal, nonmetal
↓	acid, base, hydride, oxide, hydroxide

First-order derivative terms

acid	**kwas**
def.	A type of compound that contains hydrogen and dissociates in water to produce positive hydrogen ions. For example, hydrogen chloride, HCl dissociates in water according to the following equation: $HCl(aq) \rightarrow H^{+}(aq) + Cl^{-}(aq)$ This definition of acids comes from Svante Arrhenius.
↑	metal, nonmetal, semimetal
↔	base
↓	acid anhydride, acidic oxide, coordination compound, oxoacid, salt

alloy	**stop**
def.	A material consisting of two or more metals (e.g. brass is an alloy of copper and zinc) or a metal and nonmetal (e.g. steel is an alloy of iron and carbon, sometimes with other metals included.
↑	metal, nonmetal

base	**zasada**
def.	A type of compound that reacts with a protonic acid to give water (and a salt). Typically, bases are metal oxides, hydroxides, or compounds (such as ammonia) that give hydroxide ions in aqueous solution. For example, sodium hydroxides, NaOH, reacts with hydrogen chloride, HCl, according to the following equation: $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$ This definition of bases comes from Svante Arrhenius.
↑	metal, nonmetal, semimetal
↔	acid, hydroxide
↓	basic oxide, coordination compound, salt

hydride	**wodorek**
def.	A chemical compound of hydrogen and another element or elements.
↑	metal, nonmetal, semimetal
↔	hydroxide, oxide
↓	covalent hydride, ionic hydride, metallic hydride

oxide	**tlenek**
def.	A binary compound formed between elements and oxygen. Oxides are compounds in which the oxidation state of oxygen is –2. Hydrogen oxide, H_2O, commonly known as water, is the most abundant molecule on Earth.
↑	metal, nonmetal, semimetal
↔	hydride, hydroxide
↓	acidic oxide, amphoteric oxide, basic oxide, oxoacid, peroxide, superoxide

hydroxide	**wodorotlenek**
def.	A metallic compound containing the ion OH^- (hydroxide ion) or containing the group –OH (hydroxyl group) bound to a metal atom. Hydroxides of typical metals are basic; those of metalloids are amphoteric. An example is sodium hydroxide, NaOH.
↑	metal, nonmetal, semimetal
↔	base, hydride, oxide
↓	salt

Second-order derivative terms

acid anhydride	**bezwodnik kwasowy**
def.	A compound that reacts with water to form an acid. For example, carbon dioxide, CO_2, reacts with water to give carbonic acid: $CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$
↑	acid
↔	acidic oxide, oxoacid

acidic oxide	**tlenek kwasowy**
def.	An oxide that either reacts with water to form an acid or reacts with a base to form a salt. For example sulfur dioxide, SO_2, reacts with water to give sulfurous acid, H_2SO_3: $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$
↑	acid, oxide
↔	oxoacid

amphoteric oxide	**tlenek amfoteryczny**
def.	An oxide that can act either as an acid or a base. In a strongly acidic environment, these oxides will act as bases; whereas in a strongly basic environment, these oxides will act as acids. An example is aluminium oxide, Al_2O_3: $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$ $Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaAl(OH)_4$
↑	oxide
↔	acidic oxide, basic oxide

basic oxide	**tlenek zasadowy**
def.	An oxide that either reacts with water to have a proton transferred to it reacts with an acid to form a salt. For example, barium oxide reacts with water to form barium hydroxide, $Ba(OH)_2$: $BaO(s) + H_2O(l) \rightarrow Ba(OH)_2(aq)$
↑	base, oxide
↔	acidic oxide, amphoteric oxide

coordination compound	**związek koordynacyjny**
def.	A compound with a central atom or ion and a group of ions or molecules surrounding it (ligands). Ligands usually have at least one pair of valence electrons. The coordination compounds are often coloured. An example is potassium hexacyanoferrate(II), $K_4[Fe(CN)_6]$.
↑	acid, base
↔	salt

covalent hydride	**wodorek kowalencyjny**
def.	A hydride formed when hydrogen reacts with a nonmetal or a semimetal. Molecular hydrides are either gases or liquids under standard conditions. Common examples include ammonia, NH_3, and silane, SiH_4.
↑	hydride
↔	ionic hydride, metallic hydride

ionic hydride	**wodorek jonowy**
def.	A hydride formed by the alkali metals and by the heavier alkaline earths. These active metals are much less electronegative than hydrogen. Consequently, hydrogen acquires electrons from them to form hydride ions, H^-, as shown below: $Ca(s) + H_2(g) \rightarrow CaH_2(s)$
↑	hydride
↔	covalent hydride, metallic hydride

metallic hydride	**wodorek metaliczny**
def.	A hydride formed when hydrogen reacts with transition metals. These compounds retain their metallic conductivity and other metallic properties. An example is titanium hydride, TiH_2.
↑	hydride
↔	covalent hydride, ionic hydride

oxoacid **= oxyacid, oxo acid, oxy-acid, oxiacid, oxacid**	**oksokwas** **= kwas tlenowy**
def.	An acid in which the acidic hydrogen is part of a hydroxyl group bound to an atom that is bound to an oxo (=O) group. Sulfuric acid, H_2SO_4, is an example.
↑	oxide
↔	acid anhydride, acidic oxide

peroxide	**nadtlenek**
def.	A compound containing an O–O bond. Peroxides are compounds in which the oxidation state of oxygen is –1. For example, Na_2O_2 is sodium peroxide.
↑	oxide
↔	superoxide

salt	**sól**
def.	A compound formed by reaction of an acid with a base, in which the hydrogen of the acid has been replaced by metal or other positive ions. Typically, salts are crystalline ionic compounds such as ammonium nitrate, NH_4NO_3.
↑	acid, base, hydroxide
↔	coordination compound

superoxide	**ponadtlenek**
def.	A compound containing the O_2^- ion. Superoxides are compounds in which the oxidation state of oxygen is – ½. For example, KO_2 is potassium superoxide.
↑	oxide
↔	peroxide

Key terms

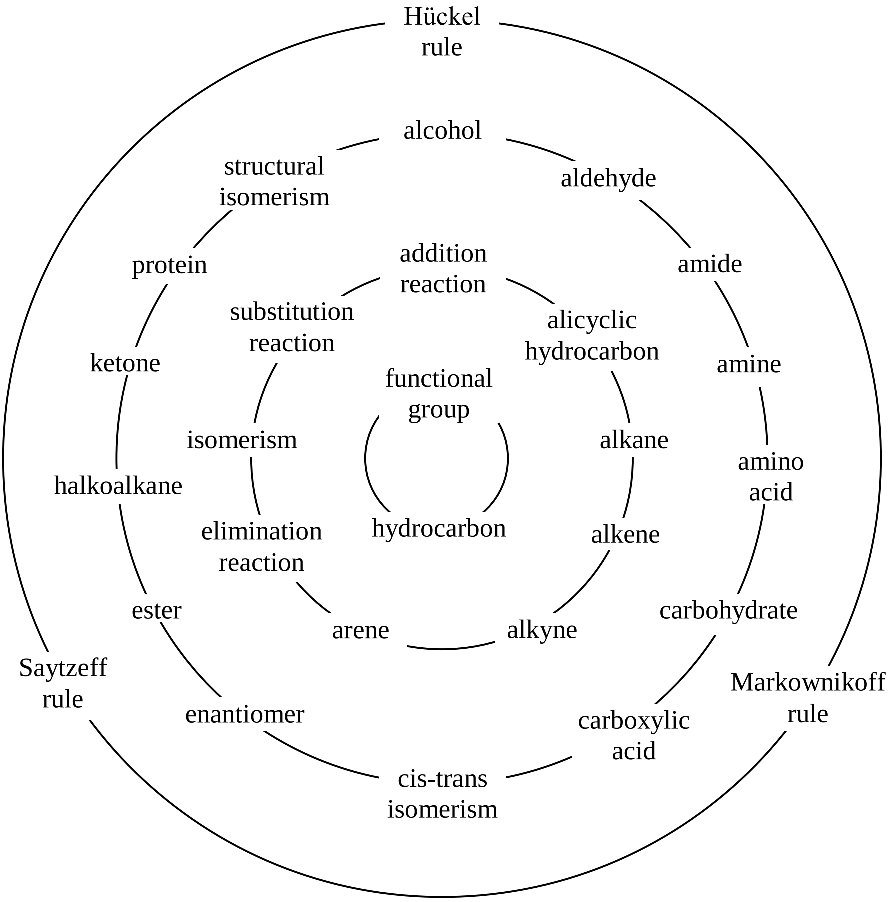
Brønsted-Lowry acid and base theory	**teoria kwasów i zasad Brønsteda-Lowry'ego**
def.	A chemical theory that provides the definitions of an acid and a base. In this theory, an acid is a proton donor (a Brønsted acid) and a base is a proton acceptor (Brønsted base). The theory was formulated by Johannes Brønsted and Thomas Lowry in 1923.
↔	Lewis acid and base theory
< >	acid, base

Lewis acid and base theory	**teoria kwasów i zasad Lewisa**
def.	A chemical theory that provides the definitions of an acid and a base. In this theory, an acid is a compound or atom that can accept a pair of electrons (Lewis acid) and a base is one that can donate an electron pair (Lewis base). The theory was formulated by Gilbert Lewis in 1923.
↔	Brønsted-Lowry acid and base theory
< >	acid, base

Module 10

Organic chemistry – chemia organiczna

The branch of chemistry concerned with compounds of carbon. In organic compounds, carbon is bonded mostly to hydrogen and sometimes to oxygen, nitrogen, sulfur, and halogens. There are a few carbon compounds that are usually treated in inorganic chemistry such as CO_2*, CO,* H_2CO_3 *and its salts.*



Primary terms

functional group	**grupa funkcyjna**
def.	An atom or a group of atoms that gives an organic compound its reactivity. Functional groups are useful for classifying various organic compounds.
↔	hydrocarbon
↓	addition reaction, elimination reaction, isomerism, substitution reaction

hydrocarbon	**węglowodór**
def.	A chemical compound that contains only carbon and hydrogen. The key feature of hydrocarbons is the presence of stable carbon-carbon bonds. In hydrocarbons, each C atom has four bonds.
↔	functional group
↓	alicyclic hydrocarbon, alkane, alkene, alkyne, arene

First-order derivative terms

addition reaction	**reakcja addycji**
def.	A chemical reaction in which one molecule adds to another. Addition reactions occur with hydrocarbons containing double or triple bonds. A simple example is the reaction of hydrogen chloride with an alkene: $HCl + CH_2{:}CH_2 \rightarrow CH_3CH_2Cl$.
↑	functional group
↔	elimination reaction, substitution reaction

alicyclic hydrocarbon	**węglowodór alicykliczny**
def.	A hydrocarbon that contains a ring of atoms and is not aromatic. The ring may contain a double carbon-carbon bond or a triple carbon--carbon bond. In systemic chemical nomenclatures the names of simple alicyclic hydrocarbons begin with cyclo-. The smallest alicyclic hydrocarbon is cyclopropane, C_3H_3.
↑	hydrocarbon
↔	arene
↓	alcohol, aldehyde, amide, amine, amino acid, carbohydrate, carboxylic acid, ester, ketone, protein

alkane	**alkan**
def.	A hydrocarbon with the general formula C_nH_{2n+2}. It contains only carbon-carbon single bonds. In systemic chemical nomenclature alkane names end in the suffix -ane. Alkanes are present in natural gas and petroleum. An example is methane, CH_4.
↑	hydrocarbon
↔	alkene, alkyne
↓	alcohol, aldehyde, amide, amine, amino acid, carbohydrate, carboxylic acid, ester, haloalkane, ketone, protein

alkene	**alkene**
def.	A hydrocarbon that contains one or more double carbon-carbon bond in its molecule. Its general formula is C_nH_{2n}. In systemic chemical nomenclature alkene names end in the suffix -ene. An example is ethene, C_2H_4.
↑	hydrocarbon
↔	alkane, alkyne

alkyne	**alkin**
def.	A hydrocarbon that contains one or more triple carbon-carbon bond in its molecule. Its general formula is C_nH_{2n-2}. In systemic chemical nomenclature alkyne names end in the suffix -yne. An example is ethyne, C_2H_2.
↑	hydrocarbon
↔	alkane, alkyne

arene **= aromatic hydrocarbon**	**aren** **= węglowodór aromatyczny**
def.	A hydrocarbon that contains a planar, cyclic arrangement of carbon atoms. Benzene, C_6H_6, is the best known example of an aromatic compound. The names of many arenes use the parent name benzene.
↑	hydrocarbon
↔	alicyclic hydrocarbon
↓	alcohol, aldehyde, amide, amine, amino acid, carbohydrate, carboxylic acid, ester, ketone, protein

elimination reaction	**reakcja eliminacji**
def.	A chemical reaction in which a pair of atoms or groups of atoms are removed from a molecule. Elimination reactions may involve the forming of a double or triple bond. An example is the reaction of ethyl bromide: $CH_3CH_2Br \rightarrow CH_2{:}CH_2 + HBr$.
↑	functional group
↔	addition reaction, substitution reaction

isomerism	**izomeria**
def.	The existence of chemical compounds that have the same molecular formulae but different molecular structures or different arrangements of atoms in space. Such compounds may have different chemical properties unless they have the same functional groups.
↑	functional group
↓	cis-trans isomerism

substitution reaction	**reakcja substytucji** **= reakcja podstawienia**
def.	A chemical reaction in which one atom (or group of atoms) replaces another atom (or group) within a molecule. Substitution reactions are typical for alkanes and aromatic hydrocarbons. An example is the reaction of benzene, C_6H_6, with bromine, Br_2: $C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr$
↑	functional group
↔	addition reaction, elimination reaction

Second-order derivative terms

alcohol	**alkohol**
def.	An organic compound that contains the –OH group (the hydroxyl group). Their chemical reactivity depends on the number of hydrogen atoms on the carbon joined to the –OH group. By oxidizing alcohols, aldehydes and ketones are formed. In systematic chemical nomenclature, alcohol names end in the suffix -ol. An example is methanol, CH_3OH.
↑	alicyclic hydrocarbon, alkane, arene
↔	aldehyde, carboxylic acid, carbohydrate, ester, haloalkane

aldehyde	**aldehyd**
def.	An organic compound that contains the group –CHO (the aldehyde group). They are formed by oxidation of alcohols. Further oxidation yields carboxylic acids. In systemic chemical nomenclature, aldehyde names end with the suffix -al. An example is methanal, HCOH.
↑	alicyclic hydrocarbon, alkane, arene
↔	alcohol, carboxylic acid, ketone

amide	**amid**
def.	An organic compound that contains the group $–CO.NH_2$ (the amide group). In some amides the hydrogen atoms on the nitrogen are replaced by one or two other organic groups respectively. They are made by heating the ammonium salt of the corresponding carboxylic acid. In systemic chemical nomenclature, amide names end in the suffix -amide. An example is ethanamide, CH_3CONH_2.
↑	alicyclic hydrocarbon, alkane, arene
↔	amine, amino acid, carboxylic acid

amine	**amina**
def.	An organic compound derived by replacing one or more of the hydrogen atoms in ammonia by organic groups. Amines that have only one hydrogen atom replaced contain the functional group $–NH_2$ (the amino group). Amines can be made by reducing amides. In systemic chemical nomenclature, amine names end in the suffix –amine. An example is methylamine, CH_3NH_2.
↑	alicyclic hydrocarbon, alkane, arene
↔	amide, amino acid

amino acid	**aminokwas**
def.	An organic compound that possesses both a carboxyl (COOH) and an amino (NH_2) group attached to the same carbon atom. Amino acids can be represented by the general formula $R–CH(NH_2)COOH$. R may be hydrogen or an organic group that determines the properties of any particular amino acid. The simplest amino acid is glycine, which has the following formula: $HO_2CCH_2NH_2$.
↑	alicyclic hydrocarbon, alkane, arene
↔	amine, carboxylic acid, protein

cis-trans isomerism	**izomeria cis-trans**
def.	The existence of chemical compounds that have the same type and number of atoms but different spatial arrangement of these atoms and bonds. In the cis isomer, the two substituent groups are oriented in the same direction, whereas in the trans isomer they are oriented in opposite directions.
↑	isomerism
↔	enantiomer, structural isomerism

carbohydrate	**węglowodan**
def.	An organic compound based on the general formula $C_x(H_2O)_y$. Carbohydrates perform many vital roles in living organisms. Glucose for example is an essential intermediate in the conversion of food to energy.
↑	alicyclic hydrocarbon, alkane, arene
↔	alcohol, aldehyde, ketone

carboxylic acid	**kwas karboksylowy**
def.	An organic compound that contains the group –CO.OH (the carboxyl group). They are formed by oxidization of aldehydes. In systematic chemical nomenclature, carboxylic-acid names end in the suffix -oic. An example is ethanoic acid, CH_3COOH.
↑	alicyclic hydrocarbon, alkane, arene
↔	alcohol, aldehyde, amide, amino acid, ester

enantiomer	**enancjomer**
def.	A chemical compound that has the same structural formula as another compound but different special arrangement of the attached atoms, so that it cannot be superimposed on its mirror image. Enantiomers possess the same physical properties and their chemical behaviour toward ordinary chemical reagents is also the same. However, they differ in chemical reactivity toward other enantiomers.
↑	isomerism
↔	cis-trans isomerism, structural isomerism

ester	**ester**
def.	An organic compound formed by reaction between alcohols and acids. Esters formed from carboxylic acids have the general formula $RCOOR'$. In systematic chemical nomenclature, ester names end in the suffix -ate. An example is ethyl ethanoate, $CH_3COOC_2H_5$.
↑	alicyclic hydrocarbon, alkane, arene
↔	alkohol, carboxylic acid

ketone	**keton**
def.	An organic compound that contains the carbonyl group (C=O) linked to two hydrocarbon groups. Ketones can be made by oxidizing alcohols. In systemic chemical nomenclature ketone names end in the suffix -one. An example is propanone, CH_3COCH_3.
↑	alicyclic hydrocarbon, alkane, arene
↔	aldehyde, carbohydrate

haloalkane **= alkyl halide**	**fluorowcoalkan** **= halogenoalkan,** **halogenek alkilu**
def.	An organic compound in which one or more hydrogen atoms of an alkane have been substituted by halogen atoms. Haloalkanes can be formed by direct reaction between alkanes and halogens using ultraviolet radiation. In systemic chemical nomenclature haloalkane names begin with the name of the halogen. An example is chloromethane, CH_3Cl.
↑	alkane
↔	alcohol

protein	**białko**
def.	An organic compound consisting of amino acids linked in a characteristic sequence which gives the compound its unique identity. Proteins are found in all living organisms. They serve as the major structural component in animal tissues.
↑	alicyclic hydrocarbon, alkane, arene
↔	amino acid

structural isomerism	**izomeria strukturalna**
def.	The existence of chemical compounds that possess the same formula but differ in the bonding arrangements of the atoms. Thus the molecules may have different molecular structures: i.e. they may be different types of compound or may simply differ in the position of the functional group within a molecule. Structural isomers usually have different physical and chemical properties.
↑	isomerism
↔	cis-trans isomerism, enantiomer

Key terms

Hückel rule	**reguła Hückla**
def.	A rule in organic chemistry used to determine whether a planar ring molecule is aromatic. If a compound has 4n + 2 (where n is zero or a positive integer) electrons which partake in double or triple bonds, it is aromatic. The foundations for the formulation of this rule were laid in 1931 by Erich Hückel.
< >	arene

Markownikoff rule = **Markovnikov rule**	**reguła Markownikowa**
def.	A rule in organic chemistry used to determine the major product formed in an addition reaction of a H–X compound to an alkene. Generally, the acid hydrogen becomes attached to the carbon with the greatest number of hydrogens. The rule was stated in 1869 by Vladimir Vasilevich Markovnikov
↔	Saytzeff rule
< >	addition reaction, alkane, alkene

Saytzeff rule = **Zaitsev rule**	**reguła Zajcewa**
def.	A rule in organic chemistry used to determine the major product formed in an elimination reaction. Generally, if the alkene is formed which has a more substituted carbon-carbon double bond. The rule was stated in 1875 by Alexander Mikhailovich Zaitsev.
↔	Markownikoff rule
< >	elimination reaction, alcohol, alkene, amine

An English-Polish index of terms

All terms included in the index below appear in the main body of the dictionary. Each English term is accompanied by its Polish equivalent and a term number, which is intended to help the user find the term in the dictionary. A term number consists in most cases of two parts divided by a slash. The first one indicates in which module a given term can be found: e.g. if the term number begins with M2 (M stands for module), the term is defined in the second module (i.e. compound). If there is no slash, the user is referred to the whole module. The second part of a term number provides information concerning the category to which a given term belongs, e.g. if the term number ends with PT, the term is a primary term. Other abbreviations used are as follows:

FT – first-order derivative term
ST – second-order derivative term
KT – key term

An arrow (→) placed after a term means that the term is synonymous with another term and the latter is used as the headword in the dictionary.

English term	**Polish term**	**Term number**
acid	kwas	M9/FT
acid anhydride	bezwodnik kwasowy	M9/ST
acid dissociation constant	stała dysocjacji kwasowej	M4/ST
acidic oxide	tlenek kwasowy	M9/ST
acidity constant → acid dissociation constant	stała kwasowości	M4/ST
activated complex	kompleks aktywny	M5/ST
activation energy	energia aktywacji	M5/ST
actual yield	wydajność rzeczywista	M3/ST
addition reaction	reakcja addycji	M10/FT
alcohol	alkohol	M10/ST
aldehyde	aldehyd	M10/ST

alicyclic hydrocarbon	węglowodór alicykliczny	M10/FT
alkane	alkan	M10/FT
alkene	alkene	M10/FT
alkyl halide	halogenek alkilu	M10/ST
alkyne	alkin	M10/FT
alloy	stop	M9/FT
alpha-decay → α-decay	rozpad alfa	M8/ST
amide	amid	M10/ST
amine	amina	M10/ST
amino acid	aminokwas	M10/ST
amount concentration	stężenie ilości substancji	M4/ST
amount-of-substance concentration → amount concentration	stężenie ilości substancji	M4/ST
ampholyte ion → zwitterion	jon obojnaczy	M2/ST
amphoteric oxide	tlenek amfoteryczny	M9/ST
anion	anion	M2/FT
anode	anoda	M7/ST
arene	aren	M10/FT
aromatic hydrocarbon → arene	węglowodór aromatyczny	M10/FT
atom	atom	M1
atomic number	liczba atomowa	M1/FT
atomic weight → relative atomic mass	ciężar atomowy	M1/FT
autodissociation → autoionization	autodysocjacja	M4/ST
autoionization	autojonizacja	M4/ST
Avogadro constant	stała Avogadro	M1/ST
band of stability	przedział trwałości	M8/KT
base	zasada	M9/FT
base dissociation constant	stała dysocjacji zasadowej	M4/ST
basic oxide	tlenek zasadowy	M9/ST

basicity constant → base dissociation constant	stała zasadowości	M4/ST
beta-decay → β-decay	rozpad beta	M8/ST
bond order	rząd wiązania	M2/ST
bond polarity	polarność wiązania	M2/ST
Brønsted-Lowry acid and base theory	teoria kwasów i zasad Brønsteda-Lowry'ego	M9/KT
buffer	bufor	M4/ST
buffer solution → buffer	roztwór buforowy	M4/ST
carbohydrate	węglowodan	M10/ST
carboxylic acid	kwas karboksylowy	M10/ST
catalyst	katalizator	M5/ST
cathode	katoda	M7/ST
cathodic protection	ochrona katodowa	M7/ST
cation	kation	M2/FT
chain reaction	reakcja łańcuchowa	M8/FT
chemical bond	wiązanie chemiczne	M2/FT
chemical element	pierwiastek chemiczny	M1/FT
chemical equilibrium	równowaga chemiczna	M3/FT
chemical formula	wzór chemiczny	M2/FT
chemical kinetics	kinetyka chemiczna	M5
chemical reaction	reakcja chemiczna	M3
chemical reaction equation	równanie reakcji chemicznej	M3/FT
chemical thermodynamics	termodynamika chemiczna	M6
cis-trans isomerism	izomeria cis-trans	M10/ST
collision theory	teoria zderzeń	M5/KT
combustion reaction	reakcja spalania	M3/FT
compound	związek chemiczny	M2
concentration	stężenie	M4/FT
coordination compound	związek koordynacyjny	M9/ST
corrosion	korozja	M7/ST
covalent bond	wiązanie kowalencyjne	M2/ST

covalent hydride	wodorek kowalencyjny	M9/ST
critical mass	masa krytyczna	M8/ST
decomposition reaction	reakcja rozkładu	M3/FT
displacement reaction	reakcja wymiany	M3/FT
disproportionation	dysproporcjonowanie	M7/ST
dissociation	dysocjacja	M4/FT
electrochemical series → electromotive series	szereg elektrochemiczny	M7/KT
electrochemistry	elektrochemia	M7
electrode	elektroda	M7/FT
electrode potential	potencjał elektrody	M7/ST
electrolysis	elektroliza	M7/ST
electrolyte	elektrolit	M4/FT
electrolytic cell	ogniwo elektrolityczne	M7/ST
electromotive force	siła elektromotoryczna	M7/ST
electromotive series	szereg napięciowy	M7/KT
electron	elektron	M1/PT
electron affinity	powinowactwo elektronowe	M1/FT
electron capture	wychwyt elektronu	M8/ST
electron dot structure → Lewis formula	wzór kropkowy	M2/ST
electron shell	powłoka elektronowa	M1/ST
electron subshell	podpowłoka elektronowa	M1/ST
electronegativity	elektroujemność	M2/FT
electronic configuration	konfiguracja elektronowa	M1/FT
elimination reaction	reakcja eliminacji	M10/FT
empirical formula	wzór cząsteczkowy	M2/ST
enantiomer	enancjomer	M10/ST
endothermic reaction	reakcja endotermiczna	M6/ST
enthalpy	entalpia	M6/FT
entropy	entropia	M6/FT
ester	ester	M10/ST
excess reactant	substrat użyty w nadmiarze	M3/ST
excited state	stan wzbudzony	M1/ST

exothermic reaction	reakcja egzotermiczna	M6/ST
Faraday’s first law of electrolysis	pierwsze prawo elektrolizy Faraday’a	M7/KT
Faraday’s second law of electrolysis	drugie prawo elektrolizy Faraday’a	M7/KT
first law of thermodynamics	pierwsza zasada termodynamiki	M6/KT
first-order reaction	reakcja pierwszego rzędu	M5/ST
functional group	grupa funkcyjna	M10/PT
galvanic cell	ogniwo galwaniczne	M7/ST
gamma radiation → γ-radiation	promieniowanie gamma	M8/ST
gamma-decay → γ-radiation	rozpad gamma	M8/ST
Gibbs free energy	entalpia swobodna	M6/FT
Gibbs function → Gibbs free energy	funkcja Gibbsa	M6/FT
ground state	stan podstawowy	M1/ST
half-life	okres półtrwania	M5/ST
half-reaction	reakcja połówkowa	M7/FT
haloalkane	fluorowcoalkan	M10/ST
heat	ciepło	M6/FT
Hess’s law	prawo Hessa	M6/KT
Hückel rule	reguła Hückla	M10/KT
Hund rules	reguły Hunda	M1/KT
hybridization	hybrydyzacja	M2/ST
hydride	wodorek	M9/FT
hydrocarbon	węglowodór	M10/PT
hydrolysis	hydroliza	M4/FT
hydroxide	wodorotlenek	M9/FT
inorganic chemistry	chemia nieorganiczna	M9
ion	jon	M2/PT
ionic bond	wiązanie jonowe	M2/ST
ionic compound	związek jonowy	M2/FT
ionic equation	równanie jonowe	M3/ST
ionic hydride	wodorek jonowy	M9/ST

irreversible process	process nieodwracalny	M6/ST
isolated system	układ izolowany	M6/FT
isomerism	izomeria	M10/FT
isotope	izotop	M1/ST
ketone	keton	M10/ST
law of conservation of mass	prawo zachowania masy	M3/KT
law of constant composition	prawo stałości składu	M2/KT
law of constant proportions → law of constant composition	prawo stosunków stałych	M2/KT
law of definite proportions → law of constant composition	prawo stosunków stałych	M2/KT
law of mass action	prawo działania mas	M3/KT
law of multiple proportions	prawo stosunków wielokrotnych	M2/KT
Le Chatelier's principle	reguła przekory	M3/KT
Le Chatelier-Braun principle → Le Chatelier's principle	reguła przekory Le Chateliera-Brauna	M3/KT
Lewis acid and base theory	teoria kwasów i zasad Lewisa	M9/KT
Lewis formula	wzór Lewisa	M2/ST
Lewis structure → Lewis formula	struktura Lewisa	M2/ST
limiting reactant	substrat użyty w niedomiarze	M3/ST
Markovnikov rule → Markownikoff rule	reguła Markownikowa	M10/KT
Markownikoff rule	reguła Markownikowa	M10/KT
mass defect	defekt masy	M8/FT
mass deficiency → mass defect	deficyt masy	M8/FT
mass number	liczba masowa	M1/ST
metal	metal	M9/PT
metallic hydride	wodorek metaliczny	M9/ST
metalloid → semimetal	metaloid	M9/PT
molar solubility	rozpuszczalność molowa	M4/ST

mole	mol	M1/FT
molecular compound	związek cząsteczkowy	M2/FT
molecular equation	równanie cząsteczkowe	M3/ST
molecular formula	wzór cząsteczkowy	M2/ST
molecular weight → relative molecular mass	ciężar cząsteczkowy	M2/FT
molecule	cząsteczka	M2/PT
Nernst equation	równanie Nernsta	M7/KT
neutralisation reaction	reakcja zobojętniania	M4/FT
neutron	neutron	M1/PT
nonmetal	niemetal	M9/PT
nuclear chemistry	chemia jądrowa	M8
nuclear binding energy	energia wiązania jądra	M8/ST
nuclear equation	równanie reakcji jądrowej	M8/FT
nuclear fission	rozszczepienie jądrowe	M8/FT
nuclear fusion	synteza jądrowa	M8/FT
nuclear reaction	reakcja jądrowa	M8/PT
nucleon number → mass number	liczba nukleonów	M1/ST
nucleus	jądro	M1/FT
nuclide	nuklid	M8/PT
octet rule	reguła oktetu	M2/KT
orbital	orbital	M1/ST
organic chemistry	chemia organiczna	M10
Ostwald's dilution law	prawo rozcieńczeń Ostwalda	M4/KT
overall reaction order	całkowity rząd reakcji	M5/FT
oxacid → oxoacid	oksokwas	M9/ST
oxiacid → oxoacid	oksokwas	M9/ST
oxidant → oxidizing agent	utleniacz	M7/FT
oxidation	utlenienie	M7/PT
oxidation state	stopień utlenienia	M7/PT
oxidation-reduction reaction	reakcja utleniania i redukcji	M7/FT

oxide	tlenek	M9/FT
oxidizing agent	utleniacz	M7/FT
oxo acid → oxoacid	oksokwas	M9/ST
oxoacid	oksokwas	M9/ST
oxyacid → oxoacid	oksokwas	M9/ST
oxy-acid → oxoacid	oksokwas	M9/ST
Pauli exclusion principle	zakaz Pauliego	M1/KT
periodic law	prawo okresowości	M1/KT
peroxide	nadtlenek	M9/ST
pH	pH	M4/ST
pOH	pOH	M4/ST
precipitation	strącanie	M4/ST
product	produkt	M3/PT
protein	białko	M10/ST
proton	proton	M1/PT
proton number → atomic number	liczba protonów	M1/FT
quantum number	liczba kwantowa	M1/ST
radical	rodnik	M1/ST
radioactive decay	rozpad promieniotwórczy	M8/FT
radioactive series	szereg promieniotwórczy	M8/KT
rate coefficient → rate constant	współczynnik szybkości	M5/FT
rate constant	stała szybkości	M5/FT
rate equation → rate law	równanie szybkości reakcji	M5/FT
rate law	prawo szybkości	M5/FT
rate-determining step	etap determinujący szybkość	M5/ST
rate-limiting step → rate-determining step	etap limitujący szybkość	M5/ST
reactant	substrat	M3/PT
reaction mechanism	mechanizm reakcji	M5/PT
reaction rate	szybkość reakcji	M5/PT

reaction step	etap reakcji	M5/FT
reactivity	reaktywność	M3/FT
redox reaction → oxidation-reduction reaction	reakcja redoks	M7/FT
reducing agent	reduktor	M7/FT
reductant → reducing agent	reduktor	M7/FT
reduction	redukcja	M7/PT
reduction potential → electrode potential	potencjał redukcyjny	M7/ST
relative atomic mass	względna masa atomowa	M1/FT
relative molar mass → relative molecular mass	masa molowa względna	M2/FT
relative molecular mass	masa cząsteczkowa względna	M2/FT
reversible process	process odwracalny	M6/ST
sacrificial protection → cathodic protection	ochrona katodowa	M7/ST
salt	sól	M9/ST
saturated solution	roztwór nasycony	M4/FT
Saytzeff rule	reguła Zajcewa	M10/KT
second law of thermodynamics	druga zasada termodynamiki	M6/KT
second-order reaction	reakcja drugiego rzędu	M5/ST
self-ionization → autoionization	autojonizacja	M4/ST
semimetal	półmetal	M9/PT
solubility	rozpuszczalność	M4/FT
solubility product	iloczyn rozpuszczalności	M4/ST
solute	substancja rozpuszczona	M4/PT
solution	roztwór	M4
solvent	rozpuszczalnik	M4/PT
spontaneous process	process spontaniczny	M6/ST
standard enthalpy of formation	standardowa entalpia tworzenia	M6/ST

standard free energy of formation	standardowa entalpia swobodna tworzenia	M6/ST
standard molar entropy	standardowa entropia molowa	M6/ST
state function	funkcja stanu	M6/PT
stoichiometric coefficient	współczynnik stechiometryczny	M3/ST
stoichiometry	stechiometria	M3/FT
structural formula	wzór strukturalny	M2/ST
structural isomerism	izomeria strukturalna	M10/ST
substitution reaction	reakcja substytucji	M10/FT
superoxide	ponadtlenek	M9/ST
surroundings	otoczenie	M6/PT
system	układ	M6/PT
theoretical yield	wydajność teoretyczna	M3/ST
third law of thermodynamics	trzecia zasada termodynamiki	M6/KT
valence electron	elektron walencyjny	M1/FT
voltaic cell → galvanic cell	ogniwo Volty	M7/ST
Zaitsev rule → Saytzeff rule	reguła Zajcewa	M10/KT
zero-order reaction	reakcja zerowego rzędu	M5/ST
zwitterion	jon obojnaczy	M2/ST
α-decay	rozpad α	M8/ST
β-decay	rozpad β	M8/ST
γ-decay → γ-radiation	rozpad γ	M8/ST
γ-radiation	promieniowanie γ	M8/ST

A Polish-English index of terms

All terms included in the index below appear in the main body of the dictionary. Each Polish term is accompanied by its English equivalent and a term number, which is intended to help the user find the term in the dictionary. A term number consists in most cases of two parts divided by a slash. The first one indicates in which module a given term can be found: e.g. if the term number begins with M2 (M stands for module), the term is defined in the second module (i.e. compound). If there is no slash, the user is referred to the whole module. The second part of a term number provides information concerning the category to which a given term belongs, e.g. if the term number ends with PT, the term is a primary term. Other abbreviations used are as follows:

FT – first-order derivative term
ST – second-order derivative term
KT – key term

An arrow (→) placed after a term means that the term is synonymous with another term and the latter is used as the headword in the dictionary.

Polish term	**English term**	**Term number**
aldehyd	aldehyde	M10/ST
alkan	alkane	M10/FT
alkene	alkene	M10/FT
alkin	alkyne	M10/FT
alkohol	alcohol	M10/ST
amid	amide	M10/ST
amina	amine	M10/ST
aminokwas	amino acid	M10/ST
anion	anion	M2/FT
anoda	anode	M7/ST
aren	arene	M10/FT

atom	atom	M1
autodysocjacja	autodissociation → autoionization	M4/ST
autojonizacja	autoionization	M4/ST
bezwodnik kwasowy	acid anhydride	M9/ST
białko	protein	M10/ST
bufor	buffer	M4/ST
całkowity rząd reakcji	overall reaction order	M5/FT
chemia jądrowa	nuclear chemistry	M8
chemia nieorganiczna	inorganic chemistry	M9
chemia organiczna	organic chemistry	M10
ciepło	heat	M6/FT
ciężar atomowy	atomic weight → relative atomic mass	M1/FT
ciężar cząsteczkowy	molecular weight → relative molecular mass	M2/FT
cząsteczka	molecule	M2/PT
defekt masy	mass defect	M8/FT
deficyt masy	mass deficiency → mass defect	M8/FT
druga zasada termodynamiki	second law of thermodynamics	M6/KT
drugie prawo elektrolizy Faraday'a	Faraday's second law of electrolysis	M7/KT
dysocjacja	dissociation	M4/FT
dysproporcjonowanie	disproportionation	M7/ST
elektrochemia	electrochemistry	M7
elektroda	electrode	M7/FT
elektrolit	electrolyte	M4/FT
elektroliza	electrolysis	M7/ST
elektron	electron	M1/PT
elektron walencyjny	valence electron	M1/FT
elektroujemność	electronegativity	M2/FT
enancjomer	enantiomer	M10/ST
energia aktywacji	activation energy	M5/ST

energia wiązania jądra	nuclear binding energy	M8/ST
entalpia	enthalpy	M6/FT
entalpia swobodna	Gibbs free energy	M6/FT
entropia	entropy	M6/FT
ester	ester	M10/ST
etap determinujący szybkość	rate-determining step	M5/ST
etap limitujący szybkość	rate-limiting step → rate-determining step	M5/ST
etap reakcji	reaction step	M5/FT
fluorowcoalkan	haloalkane	M10/ST
funkcja Gibbsa	Gibbs function → Gibbs free energy	M6/FT
funkcja stanu	state function	M6/PT
fuzja jądrowa	nuclear fusion	M8/FT
grupa funkcyjna	functional group	M10/PT
halogenek alkilu	alkyl halide	M10/ST
halogenoalkan	haloalkane	M10/ST
hybrydyzacja	hybridization	M2/ST
hydroliza	hydrolysis	M4/FT
iloczyn rozpuszczalności	solubility product	M4/ST
izomeria	isomerism	M10/FT
izomeria cis-trans	cis-trans isomerism	M10/ST
izomeria strukturalna	structural isomerism	M10/ST
izotop	isotope	M1/ST
jądro	nucleus	M1/FT
jon	ion	M2/PT
jon obojnaczy	ampholyte ion → zwitterion	M2/ST
jon obojnaczy	zwitterion	M2/ST
katalizator	catalyst	M5/ST
kation	cation	M2/FT
katoda	cathode	M7/ST
keton	ketone	M10/ST
kinetyka chemiczna	chemical kinetics	M5

kompleks aktywny	activated complex	M5/ST
konfiguracja elektronowa	electronic configuration	M1/FT
korozja	corrosion	M7/ST
kwas	acid	M9/FT
kwas karboksylowy	carboxylic acid	M10/ST
kwas tlenowy	oxoacid	M9/ST
liczba atomowa	atomic number	M1/FT
liczba kwantowa	quantum number	M1/ST
liczba masowa	mass number	M1/ST
liczba nukleonów	nucleon number → mass number	M1/ST
liczba protonów	proton number → atomic number	M1/FT
masa cząsteczkowa względna	relative molecular mass	M2/FT
masa krytyczna	critical mass	M8/ST
masa molowa względna	relative molar mass → relative molecular mass	M2/FT
mechanizm reakcji	reaction mechanism	M5/PT
metal	metal	M9/PT
metaloid	metalloid → semimetal	M9/PT
mol	mole	M1/FT
nadtlenek	peroxide	M9/ST
neutron	neutron	M1/PT
niedobór masy	mass deficiency → mass defect	M8/FT
niemetal	nonmetal	M9/PT
nuklid	nuclide	M8/PT
ochrona katodowa	cathodic protection	M7/ST
ogniwo elektrolityczne	electrolytic cell	M7/ST
ogniwo galwaniczne	galvanic cell	M7/ST
ogniwo Volty	voltaic cell → galvanic cell	M7/ST
okres połowicznego zaniku	half-life	M5/ST
okres półtrwania	half-life	M5/ST

oksokwas	oxoacid	M9/ST
oksydacja	oxidation	M7/PT
orbital	orbital	M1/ST
otoczenie	surroundings	M6/PT
pH	pH	M4/ST
pierwiastek chemiczny	chemical element	M1/FT
pierwsza zasada termodynamiki	first law of thermodynamics	M6/KT
pierwsze prawo elektrolizy Faraday'a	Faraday's first law of electrolysis	M7/KT
podpowłoka elektronowa	electron subshell	M1/ST
pOH	pOH	M4/ST
polarność wiązania	bond polarity	M2/ST
półmetal	semimetal	M9/PT
ponadtlenek	superoxide	M9/ST
potencjał elektrody	electrode potential	M7/ST
potencjał redukcyjny	reduction potential → electrode potential	M7/ST
powinowactwo elektronowe	electron affinity	M1/FT
powłoka elektronowa	electron shell	M1/ST
prawo działania mas	law of mass action	M3/KT
prawo Hessa	Hess's law	M6/KT
prawo okresowości	periodic law	M1/KT
prawo rozcieńczeń Ostwalda	Ostwald's dilution law	M4/KT
prawo stałości składu	law of constant composition	M2/KT
prawo stosunków stałych	law of constant proportions → law of constant composition	M2/KT
prawo stosunków stałych	law of definite proportions → law of constant composition	M2/KT
prawo stosunków wielokrotnych	law of multiple proportions	M2/KT
prawo szybkości	rate law	M5/FT
prawo zachowania masy	law of conservation of mass	M3/KT
process nieodwracalny	irreversible process	M6/ST

process odwracalny	reversible process	M6/ST
process spontaniczny	spontaneous process	M6/ST
produkt	product	M3/PT
promieniowanie gamma	gamma radiation → γ-radiation	M8/ST
promieniowanie γ	γ-radiation	M8/ST
proton	proton	M1/PT
przedział trwałości	band of stability	M8/KT
reakcja addycji	addition reaction	M10/FT
reakcja analizy	decomposition reaction	M3/FT
reakcja chemiczna	chemical reaction	M3
reakcja drugiego rzędu	second-order reaction	M5/ST
reakcja egzotermiczna	exothermic reaction	M6/ST
reakcja eliminacji	elimination reaction	M10/FT
reakcja endotermiczna	endothermic reaction	M6/ST
reakcja jądrowa	nuclear reaction	M8/PT
reakcja łańcuchowa	chain reaction	M8/FT
reakcja neutralizacji	neutralisation reaction	M4/FT
reakcja pierwszego rzędu	first-order reaction	M5/ST
reakcja podstawienia	substitution reaction	M10/FT
reakcja połówkowa	half-reaction	M7/FT
reakcja redoks	redox reaction → oxidation-reduction reaction	M7/FT
reakcja rozkładu	decomposition reaction	M3/FT
reakcja spalania	combustion reaction	M3/FT
reakcja substytucji	substitution reaction	M10/FT
reakcja utleniania i redukcji	oxidation-reduction reaction	M7/FT
reakcja wymiany	displacement reaction	M3/FT
reakcja zerowego rzędu	zero-order reaction	M5/ST
reakcja zobojętniania	neutralisation reaction	M4/FT
reaktywność	reactivity	M3/FT
redukcja	reduction	M7/PT

reduktor	reducing agent	M7/FT
reguła Hückla	Hückel rule	M10/KT
reguła Markownikowa	Markownikoff rule	M10/KT
reguła oktetu	octet rule	M2/KT
reguła przekory	Le Chatelier's principle	M3/KT
reguła przekory Le Chateliera-Brauna	Le Chatelier-Braun principle → Le Chatelier's principle	M3/KT
reguła Zajcewa	Saytzeff rule	M10/KT
reguły Hunda	Hund rules	M1/KT
rodnik	radical	M1/ST
rodzina promieniotwórcz	radioactive series	M8/KT
równanie cząsteczkowe	molecular equation	M3/ST
równanie jonowe	ionic equation	M3/ST
równanie kinetyczne	rate law	M5/FT
równanie Nernsta	Nernst equation	M7/KT
równanie reakcji chemicznej	chemical reaction equation	M3/FT
równanie reakcji jądrowej	nuclear equation	M8/FT
równanie szybkości reakcji	rate equation → rate law	M5/FT
równowaga chemiczna	chemical equilibrium	M3/FT
rozpad alfa	alpha-decay → α-decay	M8/ST
rozpad beta	beta-decay → β-decay	M8/ST
rozpad gamma	gamma-decay → γ-radiation	M8/ST
rozpad promieniotwórczy	radioactive decay	M8/FT
rozpad α	α-decay	M8/ST
rozpad β	β-decay	M8/ST
rozpad γ	γ-decay → γ-radiation	M8/ST
rozpuszczalnik	solvent	M4/PT
rozpuszczalność	solubility	M4/FT
rozpuszczalność molowa	molar solubility	M4/ST
rozszczepienie jądra atomu	nuclear fission	M8/FT

rozszczepienie jądrowe	nuclear fission	M8/FT
roztwór	solution	M4
roztwór buforowy	buffer solution → buffer	M4/ST
roztwór nasycony	saturated solution	M4/FT
rząd wiązania	bond order	M2/ST
siła elektromotoryczna	electromotive force	M7/ST
sól	salt	M9/ST
stała Avogadro	Avogadro constant	M1/ST
stała dysocjacji kwasowej	acid dissociation constant	M4/ST
stała dysocjacji kwasu	acid dissociation constant	M4/ST
stała dysocjacji zasadowej	base dissociation constant	M4/ST
stała dysocjacji zasady	base dissociation constant	M4/ST
stała kwasowości	acidity constant → acid dissociation constant	M4/ST
stała szybkości	rate constant	M5/FT
stała zasadowości	basicity constant → base dissociation constant	M4/ST
stan podstawowy	ground state	M1/ST
stan wzbudzony	excited state	M1/ST
standardowa entalpia swobodna tworzenia	standard free energy of formation	M6/ST
standardowa entalpia tworzenia	standard enthalpy of formation	M6/ST
standardowa entropia molowa	standard molar entropy	M6/ST
stechiometria	stoichiometry	M3/FT
stężenie	concentration	M4/FT
stężenie ilości substancji	amount concentration	M4/ST
stężenie ilości substancji	amount-of-substance concentration → amount concentration	M4/ST
stężenie molowe	amount concentration	M4/ST
stop	alloy	M9/FT
stopień utlenienia	oxidation state	M7/PT
strącanie	precipitation	M4/ST

struktura Lewisa	Lewis structure → Lewis formula	M2/ST
substancja rozpuszczona	solute	M4/PT
substrat	reactant	M3/PT
substrat użyty w nadmiarze	excess reactant	M3/ST
substrat użyty w niedomiarze	limiting reactant	M3/ST
synteza jądrowa	nuclear fusion	M8/FT
szereg elektrochemiczny	electrochemical series → electromotive series	M7/KT
szereg napięciowy	electromotive series	M7/KT
szereg promieniotwórczy	radioactive series	M8/KT
szybkość reakcji	reaction rate	M5/PT
teoria kwasów i zasad Brønsteda-Lowry'ego	Brønsted-Lowry acid and base theory	M9/KT
teoria kwasów i zasad Lewisa	Lewis acid and base theory	M9/KT
teoria zderzeń	collision theory	M5/KT
termodynamika chemiczna	chemical thermodynamics	M6
tlenek	oxide	M9/FT
tlenek amfoteryczny	amphoteric oxide	M9/ST
tlenek kwasowy	acidic oxide	M9/ST
tlenek zasadowy	basic oxide	M9/ST
trzecia zasada termodynamiki	third law of thermodynamics	M6/KT
układ	system	M6/PT
układ izolowany	isolated system	M6/FT
utleniacz	oxidizing agent	M7/FT
utlenienie	oxidation	M7/PT
węglowodan	carbohydrate	M10/ST
węglowodór	hydrocarbon	M10/PT
węglowodór alicykliczny	alicyclic hydrocarbon	M10/FT
węglowodór aromatyczny	aromatic hydrocarbon → arene	M10/FT
wiązanie chemiczne	chemical bond	M2/FT
wiązanie jonowe	ionic bond	M2/ST
wiązanie kowalencyjne	covalent bond	M2/ST

wodorek	hydride	M9/FT
wodorek jonowy	ionic hydride	M9/ST
wodorek kowalencyjny	covalent hydride	M9/ST
wodorek metaliczny	metallic hydride	M9/ST
wodorotlenek	hydroxide	M9/FT
współczynnik stechiometryczny	stoichiometric coefficient	M3/ST
współczynnik szybkości	rate coefficient → rate constant	M5/FT
wychwyt elektronu	electron capture	M8/ST
wydajność praktyczna	actual yield	M3/ST
wydajność rzeczywista	actual yield	M3/ST
wydajność teoretyczna	theoretical yield	M3/ST
względna masa atomowa	relative atomic mass	M1/FT
wzór chemiczny	chemical formula	M2/FT
wzór cząsteczkowy	empirical formula	M2/ST
wzór cząsteczkowy	molecular formula	M2/ST
wzór kropkowy	electron dot structure → Lewis formula	M2/ST
wzór Lewisa	Lewis formula	M2/ST
wzór strukturalny	structural formula	M2/ST
zakaz Pauliego	Pauli exclusion principle	M1/KT
zasada	base	M9/FT
związek chemiczny	compound	M2
związek cząsteczkowy	molecular compound	M2/FT
związek jonowy	ionic compound	M2/FT
związek koordynacyjny	coordination compound	M9/ST

An English-Polish list of chemical elements

English name	Polish name	Symbol
actinium	aktyn	Ac
silver	srebro	Ag
aluminium	glin	Al
americium	ameryk	Am
agron	argon	Ar
arsenic	arsen	As
astatine	astat	At
gold	złoto	Au
boron	bor	B
barium	bar	Ba
beryllium	beryl	Be
bohrium	bohr	Bh
bismuth	bizmut	Bi
berkelium	berkel	Bk
bromine	brom	Br
carbon	węgiel	C
calcium	wapń	Ca
cadmium	kadm	Cd
cerium	cer	Ce
californium	kaliforn	Cf
chlorine	chlor	Cl
curium	kiur	Cm
cobalt	kobalt	Co
chromium	chrom	Cr
caesium	cez	Cs
copper	miedż	Cu

dubnium	dubn	Db
darmstadtium	darmsztadt	Ds
dysprosium	dysproz	Dy
erbium	erb	Er
einsteinium	einstein	Es
europium	europ	Eu
fluorine	fluor	F
iron	żelazo	Fe
fermium	ferm	Fm
francium	frans	Fr
gallium	gal	Ga
gadolinium	gadolin	Gd
germanium	german	Ge
hydrogen	wodór	H
helium	hel	He
hafnium	hafn	Hf
mercury	rtęć	Hg
holmium	holm	Ho
hassium	has	Hs
iodine	jod	I
indium	ind	In
iridium	iryd	Ir
potassium	potas	K
krypton	krypton	Kr
lanthanum	lantan	La
lithium	lit	Li
lawrencium	lorens	Lr
lutetium	lutet	Lu
mendelevium	mendelew	Md
magnesium	magnez	Mg
manganese	mangan	Mn
molybdenum	molibden	Mo

meitnerium	meitner	Mt
nitrogen	azot	N
sodium	sód	Na
niobium	niob	Nb
neodymium	neodym	Nd
neon	neon	Ne
nickel	nikiel	Ni
nobelium	nobel	No
neptunium	neptun	Np
oxygen	tlen	O
osmium	osm	Os
phosphorus	fosfor	P
protactinium	protaktyn	Pa
lead	ołów	Pb
palladium	pallad	Pd
promethium	promet	Pm
polonium	polon	Po
praseodymium	prazeodym	Pr
platinum	platyna	Pt
plutonium	pluton	Pu
radium	rad	Ra
rubidium	rubid	Rb
rhenium	ren	Re
ruthefordium	rutheford	Rf
roentgenium	roentgen	Rg
rhodium	rod	Rh
radon	radon	Rn
ruthenium	ruten	Ru
sulfur	siarka	S
antimony	antymon	Sb
scandium	skand	Sc
selenium	selen	Se
seaborgium	seaborg	Sg

silicon	krzem	Si
samarium	samar	Sm
tin	cyna	Sn
strontium	stront	Sr
tantalum	tantal	Ta
terbium	terb	Tb
technetium	technet	Tc
tellurium	tellur	Te
thorium	tor	Th
titanium	tytan	Ti
thallium	tal	Tl
thulium	tul	Tm
uranium	uran	U
vanadium	wanad	V
tungsten	wolfram	W
xenon	ksenon	Xe
yttrium	itr	Y
ytterbium	iterb	Yb
zinc	cynk	Zn
zirconium	cyrkon	Zr

Conclusions

Having made both theoretical and practical considerations concerning a model for an English-Polish dictionary of chemical terminology and having illustrated them by including a sample of the dictionary, it seems fitting to give an overview of the conclusions and suggest potential avenues for future research. This section has been written with that very aim in mind.

The process of constructing a model entails, among other things, answering three questions, i.e. 1) what will be modelled? 2) what will serve as a model? and 3) what principles will be followed when creating and implementing the model? Although the title of this book hints at the answers, they have been fleshed out over the course of three chapters so that a coherent framework for the intended model could be established.

As regards the first question, English (and Polish) terminology in the field of chemistry was chosen to be modelled. In order to answer the question more fully, the meanings of *terminology* and *term* were discussed. Apart from enabling a set of criteria for termhood to be arrived at so that these could be used when deciding which units to include as terms in the dictionary, the relevant sections also offered some explanation as to why *term* is sometimes seen as a flawed term and why its definitions can differ. It was suggested that the existence of numerous definitions of *term* was a perfect illustration of its multi-faceted nature and of its flexibility, one that has enabled it to be interpreted and reinterpreted, thus proving to be its strength, rather than weakness. The discussion of chemistry as a science helped to shed some light on what exactly might be called a chemical term and led to the conclusion that chemistry relies to a certain extent on other sciences, which is reflected in its terminology. Chemical terminology was described as being rich, varied and – to a significant portion of society at large – impenetrable, the latter issue being attributable to its semantics. It was argued that the nature of chemical terminology is largely shaped by its subject matter. This was illustrated by exploring selected aspects involved in naming chemical substances. Given the vast number of existing substances as well as the speed at which new substances are identified, a systematic system of nomenclature was found to be an absolute necessity. Particular attention was devoted to the IUPAC nomenclature system, which exhibits a number of interesting characteristics, including its ability to produce names for substance that have yet to be identified, its ability to assign names to even the most complex of compounds, which may lead to unpronounceable names, and finally, its ability to yield different names for the same compound.

As regards the second and third questions mentioned earlier, a systematic dictionary was chosen and several of its compilation principles were discussed. In order to provide a background for subsequent sections, the relationships between general lexicology, general lexicography, terminology, and terminography were briefly discussed. A tentative communicative model for terminological dictionaries was formulated that sees terminological dictionaries as specialised texts produced by a terminographer, intended for the user, and based on specialised texts produced by subject-field specialists. After a general discussion of selected principles of compiling terminological dictionaries, the focus was placed on systematic dictionaries. One of the most salient features of this type of dictionary was found to be the fact that it attempts to pinpoint the location of terms within the conceptual network of a given discipline. Systematic dictionaries were described as being based on the conceptual classification of terms into primary terms, first-order derivative terms, second-order derivative terms, and key terms. The most important criterion for such a classification is conceptual derivation, a concept whose definition was formulated for the purposes of the present book. It was suggested that conceptual derivation can also be used to analyse the development of subject-field terminology and this has important implications for learning it, one of them being that the use of systematic dictionaries may be conducive to the teaching/learning process. General reflections on the nature of systematic dictionaries helped to lay the foundations for the design of a particular dictionary model tailored to the needs of a specific target group. It was assumed that the dictionary would be especially useful for native Polish users who are beginners when it comes to English terminology and would like to study it or revise it in a systematic manner. Based on this assumption, macrostructural and microstructural decisions were made and they were described in Chapter 2. Since the book also provides an illustration of what a systematic dictionary may look like, instead of summarising this information, some general comments about compiling systematic dictionaries are worth making:

1) Just as there is no ultimate dictionary that is all things to all men, no ultimate systematic dictionary exists. The aims, the subject and the target users may differ from dictionary to dictionary, affecting their structure and content. Despite this potential variety, one constant in dictionary design remains to reign supreme: the primacy of user needs.
2) If the number of terms to be described in the dictionary proves excessively large, it may be beneficial to divide them into modules. If such a decision is taken, ordering individual modules in such a way that indicates their thematic progression seems particularly useful.
3) Within each module, it is advisable to introduce individual categories of terms in the following order: primary terms, first-order derivative terms, second-order derivative terms, and key terms. In this way, no term precedes the term that they are derived from.
4) For every term described in the dictionary, the provision of information on their related terms needs to be given some thought. This includes in particular including information on: terms from which a given term is derived, terms that derive from a given term, and closely related terms that belong to the same class of terms (primary terms, first-order derivative terms, etc.). Additionally, in the case of key terms, information can be provided with respect to which terms are governed by them.
5) Since systematic dictionaries do not arrange the entries according to the alphabet, including at least one alphabetically-ordered index is necessary.

It is hoped that the present book will be of use to at least two areas of academia: that concerned with conceptual derivation, and that concerned with systematic dictionaries. As regards the former, a natural application of the framework described in the book could involve synchronic and diachronic studies of terminology. It would also be useful to test the framework on a larger body of terms from a single field with the aim of establishing a network of their interdependencies and ascertain the primary terms of the field, its derivative terms of different order, and key terms. Another extension that seems promising involves analysing terms from various subject fields. By extending the number of terms under analysis as well as the range of subject fields, the limits of the method may be identified, allowing for the framework to be refined. As regards potential new directions for the study of systematic dictionaries, several suggestions can be made as well. Here, too, the points made earlier about focusing on a greater number of terms as well as shifting attention to other subject fields are relevant and can be easily implemented. It would also be worth investigating whether the way in which terms were arranged in the dictionary, and the way their related terms were indicated, could be improved. Given the importance of electronic dictionaries, the question of the relevance of the proposed model to the electronic medium merits attention too. Finally, the claim regarding the potential of systematic dictionaries for teaching and learning would benefit from empirical verification, preferably through user studies.

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Streszczenie

Celem pracy jest opracowanie modelu angielsko-polskiego systemowego słownika terminologii chemicznej dostosowanego do potrzeb odbiorców o niewielkiej znajomości zagadnień chemicznych. Realizacja tak wyznaczonego celu została podzielona na dwa etapy, co znalazło odzwierciedlenie w podziale na dwie zasadnicze części (rozdziały 1–2 oraz rozdział 3), z których ta druga stanowi właściwy słownik.

W pierwszym rozdziale poruszono zagadnienia istotne dla przedmiotu słownika, czyli terminologii chemicznej, co pozwoliło na stworzenie terminologicznych podstaw modelu. Rozdział otwiera omówienie znaczeń *terminologii* oraz *terminu*. Oba te wyrazy są kluczowe dla niniejszej pracy i cechują się polisemią, co sprawia, że ich użycie wymaga objaśnienia. W dalszej części rozdziału skupiono się na wybranych jednostkach podobnych terminom oraz omówiono podział wewnętrzny terminów. Tego typu klasyfikacje są w znacznym stopniu uzależnione od definicji *terminu*, na co również zwrócono uwagę. Pozostałą część rozdziału poświęcono chemii oraz jej terminologii. Dokonano ogólnego zarysu zakresu przedmiotowego chemii, aby na tej podstawie wskazać zależności pomiędzy dyscypliną i właściwościami jej terminologii. Omówienie kwestii specyfiki terminologii chemicznej zamyka rozdział pierwszy pracy.

W rozdziale drugim skupiono się na modelu wybranym do reprezentowania angielskiej (i polskiej) terminologii z zakresu chemii, tj. na słowniku systemowym, co pozwoliło na stworzenie terminograficznych podstaw modelu. Punktem wyjścia było przedstawienie terminografii oraz nakreślenie relacji między nią i pokrewnymi dziedzinami. Następnie pokrótce scharakteryzowano słowniki terminologiczne, do których należy proponowany słownik, oraz przybliżono zasady ich tworzenia, podkreślając kwestie szczególnie istotne dla niniejszej książki. W dalszej kolejności uwagę skierowano na zagadnienia słowników systemowych. Na podstawie literatury przedmiotu opisano ich cechy oraz omówiono ich znaczenie. Rozdział wieńczy omówienie założeń modelu słownika, które zostały wykorzystane przy tworzeniu rozdziału trzeciego. W szczególności opisano cele słownika, jego grupę docelową oraz wynikające z tych założeń wnioski dla makrostruktury i mikrostruktury słownika. Poszczególne rozwiązania terminograficzne zostały opatrzone uzasadnieniem.

Rozdział trzeci stanowi najbardziej praktyczną część niniejszej książki. Zawarto w nim angielsko-polski słownik systemowy terminologii chemicznej, podzielony na 10 modułów tematycznych, z których każdy ilustruje zasady przedstawione w poprzednich rozdziałach. W rozdziale znalazł się również wstęp dla użytkownika, angielsko-polski indeks terminów, polsko-angielski indeks terminów oraz angielsko-polska lista pierwiastków chemicznych. Pracę kończą wnioski oraz bibliografia.

Słowa kluczowe
język specjalistyczny, leksykografia, słownik systemowy,
słownik terminologiczny, termin, terminografia, terminologia

Keywords
lexicography, specialised language, systematic dictionary, term,
terminological dictionary, terminography, terminology